MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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Lieut.-General J. F. TENNANT, C.I.E., R.E., F.R.S., President, in the Chair.

Robert Isaac Finnemore, J.P., F.R.Hist.Soc., Durban, Natal;
William Friese-Greene, 92 Piccadilly, W.;
George Higgs, 467 West Derby Road, Liverpool;
Neville Holden, High Street, Lancaster; and
Harold Jacoby, B.A., Columbia College Observatory, New York,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Bhuban Mokan Bandyopadhyay, B.A., F.R.Hist.Soc., Professor of Science and Lecturer on Astronomy at the Christian College, Lucknow (proposed by Captain S. G. Burrard);
John Billington Booth, J.P., Preston, Lancashire (proposed by Dr. R. Copeland);
Joseph Brooks, Trigonometrical Survey of New South Wales, Lands Department, Sydney, N.S. Wales (proposed by R. L. J. Ellery);
James S. Browne, Lamp Manufacturer, 170 Sloane Street, S.W. (proposed by the Rev. T. Mackereth);
Edward Tremlett Carter, Assoc. Inst. E.E., School of Electrical Engineering, 12 Princes Street, Hanover Square, W. (proposed by Andrew C. D. Crommelin);
Rev. A. L. Cortie, S.J., St. Beuno's College, St. Asaph, North Wales (proposed by W. H. M. Christie);

William Bladen Croft, M.A., Physics Master of Winchester College, 9 College Street, Winchester (proposed by Professor C. Pritchard) ;

James Gallaher, The Limes, Leyton, and St. George's House, Eastcheap, E.C. (proposed by James Glaisher) ;

Rev. H. Grattan Guinness, D.D., F.R.Hist.Soc., F.R.G.S., Harley House, Bow, and Cliff House, Curbar, Derbyshire (proposed by E. Walter Maunder) ;

C. W. H. Jeavons, Analyst, Horseley Place, Tipton, Staffordshire (proposed by A. Taylor) ;

John Mitchell, Brockholes, Huddersfield (proposed by Joseph Gledhill) ;

William M. Pierson, San Francisco, California, U.S.A. (proposed by Edward E. Barnard) ;

James Lidderdale Scott, Shanghai, China (proposed by L. S. Little) ;

Arthur Laidlaw Selby, M.A., Assistant Professor of Physics in the University College of South Wales and Monmouthshire, Cardiff (proposed by Professor R. B. Clifton) ;

Rev. Walter Sidgreaves, S.J., Director of the Observatory, and Professor of Physics, Stonyhurst College, Blackburn, Lancashire (proposed by W. H. M. Christie) ;

John Peter George Smith, Sweyney Cliff, Coalport, Shropshire (proposed by Sir William Thomson) ;

Arthur J. Walker, New College, Oxford (proposed by Professor C. Pritchard).

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155 presents were announced as having been received since the last meeting, including, among others :—

Birmingham (J.), The Red Stars, new edition by Rev. T. E. Espin, presented by Rev. T. E. Espin.

Catalog der Astronomischen Gesellschaft, Zone + 55° bis + 65°, Zone + 1° bis + 5°, presented by the Society.

Cayley (A.), Collected Mathematical Papers, vol. 3, presented by the Author.

Clerke (A. M.), The System of the Stars, presented by the Author.

Engelhardt (B. d'), Observations Astronomiques faites . . . dans son Observatoire à Dresde, IIme. partie, presented by the Author.

Opere de Galileo Galilei, Edizione Nazionale, vol. 1, presented by the Italian Government.

Schubert (E.), Tables of Melpomene and Eunomia, presented by the American Nautical Almanac Office.

Tisserand (F.), Traité de Mécanique Céleste, tome 2, presented by the Author.

Winterhalter (A. G.), The International Astrophotographic Congress, and visit to European Observatories, &c., presented by the U.S. Naval Observatory.

Ahmed Mukhtar Pasha, The Reform of the Calendar, translated by Sir J. W. Redhouse, K.C.M.G., presented by Sir J. W. Redhouse.

Photographs of the Moon taken with the Great Equatoreal of the Lick Observatory (3 original negatives and one glass positive). Photograph of the Total Solar Eclipse, 1889, Dec. 22, by J. M. Schaeberle (2 glass positives). Photograph of *Jupiter*, taken with the Great Equatoreal of the Lick Observatory, by E. S. Holden (glass positive — enlargement). Comparative photographs of the high Sun and low Sun spectra, presented by Mr. F. McClean. } Presented by the Lick Observatory.

On the Real and Apparent Variations of the Latitude of Greenwich. By Professor F. Folie.

(*Communicated by the Astronomer Royal.*)

The real variations of latitude are, we know, given by the formula

$$r \cos (int + \beta).$$

The values of r given by Peters and Downing * are

$$0''{\cdot}079 \text{ and } 0''{\cdot}075.$$

The same value, determined by me from the diurnal variations in R.A., deduced from the observations of W. Struve at Dorpat in 1823–25, is:

1823	...	...	$0''{\cdot}080$
1824	...	...	$0''{\cdot}075$
1825	...	...	$0''{\cdot}086$

The value of the constant β, determined by Peters, Nyrén, and Downing,† are, the last being brought back to Dorpat:

1842	...	...	$341^{\circ}{\cdot}6$
1850	...	...	224
1872	...	...	175

Astronomers have not yet been able to bring these values into accordance by assuming the adopted increase of 430° (about) yearly, corresponding to a period of 305 days.

Theoretical reasons, agreeing with my ideas as to the constitution of the central nucleus of the Earth, have made me doubt the

* I cannot use those of Nyrén, because they are too discordant.

† Peters (*A. N.*, xxii., 1845, 128). Nyrén (*St. Pétersbourg Me* 1873, no. 10, pp. 37, 38). Downing (*M. N.*, xl., 1880, pp. 431, 432).

accuracy of this period,* and I have tried to deduce it from the observations, after having found from those of W. Struve (cited above) that the value of 430° is considerably too large. Here are the values deduced from the observations, at April 1 of each of the three years:

1823	...	...	236° 43′	Mean 246°.
1824	...	...	247 23	
1825	...	...	254 6	

A series of observations by Preuss has given me for April 1, 1838, 310°. The difference, 310 − 246 = 64° divided by 1838 − 1824 = 14 gives only 4°·5, or an increase of 364°·5 yearly, which is too small. I divide 360° + 64° = 426° by 14, which gives 30°·5 nearly, and 390°·5 for the annual increase.

Applying this to the observations, I find

			Residuals.
1824·0	151°	W. Struve	...
1838·0	151° + 14 × 30°·5 = 218°	Preuss, 221°	−3°
1842·0	151° + 18 × 30°·5 = 340°	Peters, 341°·6	−1°·6
1850·0	151° + 26 × 30°·5 = 224°	Nyrén, 224°	0
1872·0	151° + 48 × 30°·5 = 175°	Downing, 175° †	0

If I take 340° for 1842, or 224° for 1850, the same annual increase will naturally give no residuals for 1850 and 1872, or for 1872.

There is no doubt, then, that the constants determined by astronomers are in as great accordance as we can desire with the annual increase of 390°·5, corresponding to a period of 336·7 days instead of 305 days, the value which has hitherto been assumed. This last number is deduced from the value 0·00327 ascribed to $\frac{C-A}{A}$. This value is exact for the Earth considered as a whole solid body. The real value being smaller, 0·00296, we must admit in conclusion that we cannot consider the Earth as a solid body in the studies of variations of latitudes.

We can, from the above, assume with confidence, for the variations of latitude of Greenwich, the formula:

$$r \cos (205° + 390°{\cdot}5\, t),$$

in which t = number of years from 1872·0 and $r = 0''{\cdot}078$, the mean of the values of Peters, Downing and Folie.

These are the results for the real variations of latitude, or the distance between the instantaneous pole and the geographical pole of the Earth. But the constant r is also, with a very slight

* See *Annuaire de l'Observatoire Royal de Bruxelles*, pour 1890, p. 299.

† Value referred to Dorpat.

difference, the constant of the *initial nutation* of the geographical pole, determined in obliquity and in longitude by the formula:

$$\Delta\theta = -r\sin[(1+i)\,nt+\beta]$$
$$\sin\theta\,\Delta\lambda = -r\cos[(1+i)\,nt+\beta],$$

whence we may deduce, as we know, $\Delta\alpha$ and $\Delta\delta$.

The apparent places of stars are, then, subject to variations of a period almost exactly diurnal, since $i = \frac{1}{336{\cdot}7}$ nearly, and no determination of latitude can be exact if not corrected for these variations. And Laplace is right in saying: "Si la valeur de r était sensible, on le reconnaîtrait par les variations journalières de la latitude," * recognising, in fact, the correction to be applied to the latitude of Greenwich, deduced from two true consecutive zenithal distances of *Polaris*, at upper and lower transits.

If δ be the *true* declination of the star, as it is *calculated by the astronomers*, $\Delta_i\delta$ the initial nutation in declination, the true *real* declination will be $\delta+\Delta_i\delta$, and we shall have for the upper transit [z=true real zenithal distance, ϕ=colatitude].

$$z = \phi - \delta - \Delta_i\delta.$$

But we see immediately that after twelve sidereal hours the sign of $\Delta_i\delta$ must change and maintain almost the same value. We have, then, for the lower transit

$$z' = \phi + \delta - \Delta_i\delta.$$

From the two equations we deduce

$$\phi = \frac{z+z'}{2} + \Delta_i\delta$$

instead of

$$\phi = \frac{z+z'}{2}$$

the value given by astronomers.

This correction is by no means to be neglected, if we admit the coefficient $0''{\cdot}078$. It is for Greenwich

$$i = \frac{1}{336{\cdot}7} \text{ or } int = 390^\circ{\cdot}5 \text{ yearly};$$
$$t = \text{sidereal days from } 1872{\cdot}0;$$
$$nt = 360^\circ \text{ for a sidereal day};$$
$$\beta = 205^\circ;$$
$$\Delta_i\delta = \sin\alpha\,\Delta_i\theta + \cos\alpha\sin\theta\,\Delta_i\lambda$$
$$= -r\cos\{(1+i)\,nt+\beta-\alpha\},$$

which expression will change its sign after twelve hours, if we neglect the half degree for the increase of it, and the colatitude

* *Mécanique Céleste*, livre v., art. 4.

deduced from each pair of observations must be corrected by this quantity, as I have said above. Is it necessary to add that if we will take the hundredth of a second of arc in account, it is quite indispensable to correct the observations for initial nutation ?

The expression in R.A. of the initial nutation is :

$$\Delta\alpha = (\cot\theta + \sin\alpha\tan\delta)\sin\theta\Delta_i\lambda - \cos\alpha\tan\delta\Delta_i\theta$$
$$= -r\{M\cos[(1+i)t+\beta] + N\sin[(1+i)t+\beta]\}.$$

M and N being respectively $\cot\theta + \sin\alpha\tan\delta$ and $\cos\alpha\tan\delta$.

If r has the value given by the determinations of Peters, Downing and myself, this correction may attain to $0^{s}.2$ of time for *Polaris*. But I think this value of r to be still doubtful, in spite of the accordance of those three determinations.

A very important consequence which arises in taking no account of the variations of latitude as also of the initial nutation, is its influence on the determination of the obliquity of the ecliptic.

If E_o = mean obliquity determined as usual, the true expression for it, at the summer solstice, is

$$E_m = E_o + \gamma\cos(int+\beta) + \gamma\sin[(1+i)nt+\beta],$$

the first term of the corrections arising from the variation of latitude, the second from the initial nutation.

At the winter solstice, this expression becomes

$$E'_m = E'_o + \gamma\cos(int'+\beta) - \gamma\sin[(1+i)nt'+\beta];$$

the sign of the correction of the initial nutation is changed because, at the solstices, when the Sun's right ascension is 90° or 270°, the initial nutations in declination,

$$\Delta_i\delta = \sin\alpha\Delta_i\theta,$$

are equal and opposite in sign.

But, at the winter solstice, t is increased by an entire number j of sidereal days, taken as unity, and twelve hours more, so that

$$t' = t + j + 12^{h}$$

and

$$E'_m = E'_o + \gamma\cos(int'+\beta) + \gamma\sin(j + nt + int' + \beta)$$
$$= E'_o + \gamma\cos(int'+\beta) + \gamma\sin(nt + int + \beta),$$

because j is a multiple of 360°.

The correction of obliquity at the summer solstice $E_m - E_o$ will be :

$$\Delta E = 2\gamma\cos\left(\frac{nt}{2} - 45^\circ\right)\sin\left(\frac{nt}{2} + 45^\circ + int + \beta\right)$$

and at the winter solstice

$$\Delta E' = 2\gamma\cos\left(\frac{nt}{2} - 45^\circ\right)\sin\left(\frac{nt}{2} + 45^\circ + int' + \beta\right).$$

These two corrections are not equal; the difference $\Delta E - \Delta E'$ will be:

$$\Delta^2 E = -4\gamma \cos\left(\frac{nt}{2} - 45^\circ\right) \sin in \frac{t'-t}{2} \cos\left(\frac{nt}{2} + 45^\circ + in\frac{t'+t}{2} + \beta\right)$$

as $t'-t$ is a half year,

$$in\frac{t'-t}{2}$$

will be equal to

$$\frac{390^\circ\cdot 5}{4} = 97^\circ\cdot 6; \text{ its sin} = 0\cdot 9915,$$

and we have then

$$\Delta^2 E = -3\cdot 966\gamma \cos\left(\frac{nt}{2} - 45^\circ\right) \cos\left(\frac{nt}{2} + 45^\circ + in\frac{t+t'}{2} + \beta\right),$$

or, if we write

$$in\frac{t'+t}{2} = int + 97^\circ\cdot 6,$$

and

$$\beta + 7^\circ\cdot 6 = \beta'$$

$$\Delta^2 E = 3\cdot 996\gamma \cos\left(\frac{nt}{2} - 45^\circ\right) \sin\left(\frac{nt}{2} + 45^\circ + int + \beta'\right).$$

We will apply the formula to the determination of obliquity for Greenwich 1872, and take for the equinox

$$\beta = 205^\circ + 0\cdot 2163 \times 390^\circ\cdot 5 = 289^\circ\cdot 5;$$

$$\beta' = \beta + 7^\circ\cdot 6 = 297^\circ\cdot 0;$$

and

$$3\cdot 996\gamma = 0''\cdot 3.$$

From the equinox to the solstice t is increased by an entire number of days + 6 hours. So that $\frac{nt}{2}$ will be $= 45^\circ$.

The expression of $\Delta^2 E$ will then be

$$\Delta^2 E = 0''\cdot 3 \cos(int + \beta') = 0''\cdot 3 \cos(97^\circ\cdot 5 + 297^\circ)$$
$$= 0''\cdot 3 \cos 34^\circ\cdot 5 = 0''\cdot 25.$$

Such is the difference existing between the obliquity determined at summer and at winter solstices in 1872, at Greenwich, if we admit as exact the determination of the initial nutation made by Downing.

Moreover, if my period of 336·7 mean days is admitted as exact by astronomers, instead of the period of 305 days, adopted until now, and the great accordance between all the determinations compels this admission, it is certain, as I have said, that we cannot consider the Earth as a solid body, for which $\frac{C-A}{A}$ oscillates, at the most, between 0·00324 and 0·00328 (taking into

account the exactness of the constants of precession and nutation), and, in consequence, the period between 304 and 306 days.

And if we cannot consider the Earth a solid body, the diurnal nutation, of which the period is half a sidereal day, certainly exists.

I estimate its coefficient to be twice as great as that of the initial nutation. It is, then, a new correction to be applied to the observations, if we will be sure of the hundredth of a second of arc.

And then, can we even be sure ?

Brussels : July 5, 1890.

Preliminary Note on the Duplicity of α Lyræ.

By A. Fowler.

(*Communicated by Professor J. Norman Lockyer, F.R.S.*)

A photographic study of stellar spectra has recently been commenced at Kensington, under the direction of Professor Lockyer, and one of the first results is the discovery that *α Lyræ* is a binary of the *β Aurigæ* and *ζ Ursæ Majoris* type. The principles of the method have already been fully stated by Professor Pickering (*Monthly Notices*, vol. L, p. 296), but it may be remarked that the evidence of duplicity depends upon the fact that when both components are travelling in opposite directions in the line of sight, the lines of the spectrum which are common will appear double, the spectrum of one being displaced towards the red and the other towards the violet. When the components are moving at right angles to the line of sight, the lines will be single. During a whole period, therefore, a given line will first appear single, let us say, then it will gradually double until a maximum is reached; it will then narrow and become single, widen to another maximum and again appear single.

In the spectrum of *α Lyræ* the principal lines are those of hydrogen, but these do not show the duplication because the separation is not greater than the thickness of the lines. A variation in width, however, amounting almost to doubling in the more refrangible lines, is very obvious. Next to the hydrogen lines the K line is strongest, and this is sufficiently fine and distinct to render the detection of duplication quite easy. The remaining lines are very faint and their duplication is not very apparent. They are only seen to be double in two or three photographs. Fourteen photographs have already been obtained, dating from October 3 to November 4, but, owing to unfavourable weather, there are long breaks in the series. There are sufficient data, however, to enable a provisional period of revolution and the probable form of the orbit to be determined.

The following table summarises the results so far obtained, the second column giving the separation of the K lines in tenth-metres, and the third the corresponding relative velocity of the two components in the line of sight:—

Date.	Separation of K Lines.	Relative Velocity in the Line of Sight.
Oct. 3, 9 P.M.	3·8	180 miles per second
„ 8, 8 „	7·8	370 „ „
„ 9, 7 „	4·9	232 „ „
„ 10, 7.20 P.M.	5·5	260 „ „
„ 11, 8.30 „	4·6	218 „ „
„ 12, 8.15 „	6·2	294 „ „
„ 14, 10 „	5·5	260 „ „
„ 17, 10 „	0·0	
„ 27, 8 „	2·3	109 „ „
„ 28, 6.30 „	0·0	
Nov. 1, 8 „	0·0	
„ 1, 8.30 „	2·3	109 „ „
„ 1, 10 „	3·8	180 „ „
„ 4, 9 „	0·0	

A discussion of these data shows that they are all fairly well satisfied by assuming a circular orbit, the plane of which almost passes through the Sun, with a period of revolution of about 24·68 hours. This is best seen when the results are plotted graphically, the variations being represented by the curve of sines. In the accompanying diagram the curve represents the variations in the distance between the K lines assuming the orbit and period to be as stated, and the dots show the actual results deduced from the photographs, the maximum separation being taken as 10 units. It will be seen that practically every dot falls in its proper place on the curve, the slight discrepancies being within the limits of error in measurement.

In the case of *ζ Ursæ Majoris* Professor Pickering found a period of about 52 days, with a maximum relative velocity of 100 miles per second, and for *β Aurigæ* a period of four days with a maximum velocity of about 150 miles per second. Vogel has further discovered by the photographic method that *Spica* is accompanied by a dim companion which completes a revolution in about 4 days, the diameter of the orbit being 6 millions of miles, and the orbital velocity about 50 miles per second. In the case of *α Lyræ*, as already stated, I have found the period to be probably about 24·68 hours, and the maximum relative velocity about 370 miles per second. This period is remarkably short, but it does not seem inconsistent with the great velocity indicated by the photograph of October 8, and is partially confirmed by

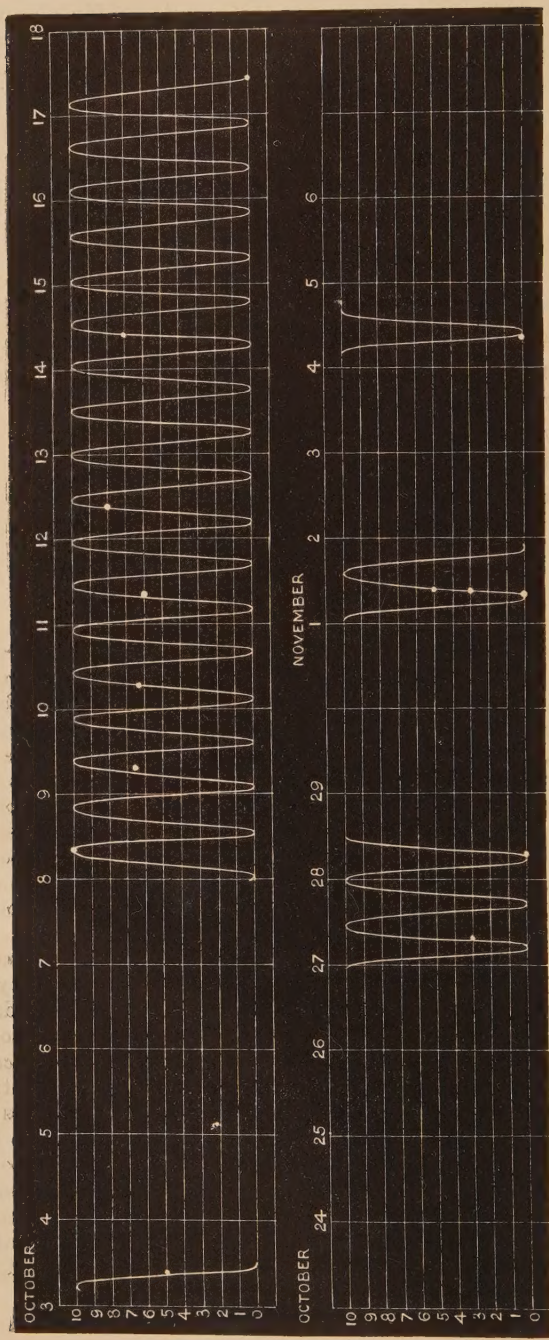

Diagram showing the variations in the separation of the K lines in the spectrum of *a Lyræ*.
(The maximum separation is taken as 10 units.)

the three photographs of November 1, taken at short intervals. The doubling of the line takes place so quickly that it is difficult to say when it is absolutely single, and hence the minima recorded in the table are only approximate.

It seems fair to assume that 370 miles per second is about the maximum relative orbital velocity, and this gives a little over five millions of miles as the distance between the components. The total mass will therefore be about $22\frac{1}{2}$ times that of the Sun, and as there is no appreciable difference in the intensity of the K lines, or of the hydrogen lines as far as can be estimated from their partial separation, the masses of the components are probably about equal. These values will, of course, require modification if the plane of the orbit does not pass through the Sun. They must not yet be regarded as final, in consequence of the absence of a series of photographs taken at short intervals. Such a series will be obtained as soon as possible; they were not taken in the first instance because it was not suspected that the period was so short. Unfavourable weather has since prevented this being done, and I have taken this opportunity of bringing my results before the Society in the hope that some other observer with better atmospheric conditions may be induced to take up the question.

The mean value of the parallax of α *Lyræ*, as determined by the Struves, Peters, and others is $0''{\cdot}16$, and if we take this as correct, the angular distance between the components at the elongations would be $0''{\cdot}008$. If Elkin's value ($0''{\cdot}034 \pm 0{\cdot}045$) be taken, the angle will be very much less, and it is not likely, therefore, that the components will ever be separated by a telescope.

The instrument employed in the investigation was the 10-inch refractor belonging to the Royal College of Science, with two prisms of $7\frac{1}{2}°$ each in front of the object-glass. The length of the spectrum from F to K is about an inch and a half, and the maximum separation of the K lines in α *Lyræ* $\frac{1}{50}$th of an inch, or $35''$. The exposure was generally a quarter of an hour.

I have to express my obligation to Messrs. Rogers and Baxandall for assistance in taking the photographs.

Royal College of Science,
South Kensington.

On the Variation of the Spectra of R Coronæ and R Scuti, and on the Spectra of R Aurigæ and R Andromedæ. By the Rev. T. E. Espin, B.A.

R Coronæ.—The observations of this star show a curious change of spectrum. Throughout the observations the star was examined on each night with different spectroscopes, and, beginning with feeble dispersion, the examination was continued till the highest dispersion the star would bear was reached.

The spectroscope was very carefully focussed on the strong F line in *a Coronæ*. I give the results of the observations in detail:—

1890, *March* 26.—Very clear; moonlight. Star about 5·8 mag. Colour, yellowish white. Nothing certain seen; sometimes irregularities, either dark or bright lines suspected.

1890, *April* 10.—Continuous spectrum, but again suspected lines, one bright one strongly suspected near the place of F, but believed more refrangible.

1890, *September* 8.—A most wonderful change has taken place in this star's spectrum. Two large absorption bands have appeared, one in the bluish-green, and one in the bluish-violet. These bands are sharply defined on the least refrangible side. Bringing the spectrum to a line, bright patches were seen far away in the violet—these may be bright lines or bright spaces. The star is now pale yellow. The magnitude still about 6.

1890, *September* 14.—The spectrum is apparently of the IV. type, since the bands fade away on the more refrangible side, but are sharply defined on the less refrangible. The band in the bluish-green was thought to be occasionally resolved into fine lines; between the two bands a bright line was suspected. The star is of the same magnitude and now pale orange.

1890, *October* 8.—Heavy mist, eventually putting a stop to telescopic work. The star is only dim, but the bands seem to have faded.

1890, *October* 10.—The star has now nearly returned to the continuous first type spectrum observed in the spring. The big band in the bluish-green has disappeared, but the band in the violet is probably there still, but faint. The bright line previously mentioned again suspected. The star is now yellowish-white, and the magnitude about the same.

R Scuti: 1890, *August* 21. *III. Type.*—The bands are faint. Bands 1, 2, 3, of Dunér's nomenclature, seen, and also 7 and 8, which are the strongest.

1890, *August* 23.—Estimated 7·2; pale orange-red; carefully examined. The spectroscope each time focussed on λ *Aquilæ*. Type III., but peculiar. The usual bands, 1, 2, 3, seen, the bands 4 and 5 faint, 7 and 8 are strong. Bringing the spectrum to a line, bright knots seen in the violet and ultra-violet, either lines or spaces.

1890, *September* 8.—The bands 4 and 5 are much better seen to-night, but the other bands remain the same. The star is now brighter.

1890, *October* 10.—The star is now about 6 mag. The III. type spectrum is no longer certainly seen. A remnant of band 7 still remains; the others have almost, if not quite, disappeared. Perhaps 8 is there.

1890, *October* 12.—The star about 6 mag. Star low, tremulous, and type doubtful. Possibly III., but very indistinct.

1890, *October* 15.—The star is about 6·5. The spectrum is again clearly III. type. Bands 7 and 8 best seen, also 1 to 4

visible. The bands are, however, faint and dim, but are larger now, and the spectrum is similar to that observed on August 21.

1890, *November* 1.—Normal III. type, and about 6·8 mag. The bands are well seen in all parts of the spectrum. Bands 7 and 8 are especially broad.

R Aurigæ: 1890, *August* 18.—Mag. 7·2; colour fine rose-red. Very fine III. type, and the spectrum appears to resemble that of *Mira* rather than *R Andromedæ*.

R Andromedæ: 1890, *August* 23.—Magnitude 7·3 ±. Bands not deep, except in the blue and violet. Bringing the spectrum to a line, several bright lines in the violet and ultra-violet suspected. F possibly bright, but not sure about this.

1890, *September* 8.—The star has increased in light, and *γ Hydrogen* and F certainly seen, but still faint.

1890, *September* 14.—Bands in the red well seen, the yellow bands faint. F very plain now.

1890, *September* 15.—The F line now a wonderful spectacle. The star is not so red, the bands are generally faint except in the red. A bright space in the yellow looks like a mass of fine bright lines. A deep band in the violet. Hγ and D_3 possibly bright.

Comparative Photographs of the High Sun and Low Sun Visible Spectra, with Notes on the Method of Photographing the Red End of the Spectrum. By Frank McClean, M.A.

The accompanying photographs represent the High Sun and the Low Sun visible spectra from (H) to (A). The High Sun spectrum has been taken, as far as possible, when the Sun's altitude was over 45°, and the Low Sun spectrum when it was under $7\frac{1}{2}°$. The depth of atmosphere traversed for the Low Sun spectrum was thus about five times that traversed for the High Sun spectrum. A few exceptions to this rule are indicated in the accompanying Table. The elastic force of aqueous vapour in the atmosphere when each photograph was taken is given in the same Table.

The photographs are in sections numbered from I. to XIII. From I. to XI. they correspond to the divisions of Ångström's chart. The scale is also about the same, but in the photographs it varies as the secant of the angle through which the grating is turned from its central position. There is a slight break in the scale between Sections IV. and V., owing to a different object-glass being employed for the violet portion of the spectrum.

The corresponding sections of the High Sun and Low Sun spectra are mounted in juxtaposition, so as to show by comparison the atmospheric groups of lines. These groups divide themselves, on inspection, into two classes. Firstly, those in which the bulk of the lines grow uniformly darker as the Sun

approaches the horizon. Secondly, those in which many of the lines become exceptionally prominent under the same circumstances, and especially when there is much moisture in the air.

To the first class belong the groups (A) (a) and (B). To the second class belong the group about (C) and (β) above it, the group called (α) by Ångström, or (C_6) by Brewster and Gladstone; the rain-band group below and about (D), and the group (δ) above (D). Also two small groups called (ς) and (ι) by Brewster and Gladstone, situated near wave-lengths 5430 and 5040. The remaining bands indicated by Brewster and Gladstone are not easily distinguishable. Indications of groups of fine atmospheric lines exist in the region of (H), but this appearance may partly be caused by the weakness of the Low Sun spectrum. Weakness in the light of the spectrum affects the photographs in much the same way as strength in the lines. In some of the groups, the fainter solar lines appear weaker in the Low Sun spectrum than in the High Sun. This indicates that the stronger lines are also shown less strong than they should be, in the Low Sun spectrum.

The moderate scale of the photographs has some advantages. The photographs thus represent the well-known features of the solar spectrum in the compact form in which they are familiar. They constitute a companion to Ångström's chart, and can be directly compared with any part of it, and the lines due to the various substances identified from it. Also corresponding photographs of the metallic spectra can be obtained by means of the induction spark, as is shown by the photographs of the iron and the iridium spectra, laid before the Society in May 1888. The main divisions of the scale of wave-lengths have been placed on the photographs from Ångström's chart. The photographs, however, are not suitable for determining any principal measurement. They are only suitable for the identification of groups of lines, and for filling in the details between standard lines, whose wave-lengths have been determined by direct observations with proper instruments.

The photographs are enlarged about $8\frac{1}{2}$ times from the original negative.

The following are a few particulars of the instruments and methods employed for obtaining the photographs, and more especially, those of the red end of the spectrum.

The spectroscopic apparatus is that which the writer has made use of with little change since 1879, with a large Rutherfurd grating which he then obtained. During the present year he has substituted a Rowland plane grating for the Rutherfurd, and these photographs are taken with it.

A fixed heliostat, commanding a large extent of true horizon, reflects the solar light into a telescope fixed parallel to the polar axis. The object-glass of this telescope is 98 inches in focal length, and it is stopped down to 4 inches aperture. Near its

focus a right-angled prism reflects the solar image horizontally into the spectroscope.

The spectroscope consists of collimating and observing telescopes of 2 inches aperture each, and respectively of 50 and 36 inches focal lengths.* These are fixed at an inclination of 16° 30′ to one another, and at their intersection the grating rotates horizontally. The positions of the grating for the different sections of the spectrum are given in the Table appended. The dispersion is double the corresponding rotation.

There are two important points with respect to the method of obtaining the photographs of the spectrum. These are, the selection of the absorption screens, and the preparation of the plates.

In the present case, for the purposes of absorption, use is made of glass cells one-sixth of an inch thick. These are filled with suitably coloured solutions, and placed on a stand in front of the slit. The colour can be chosen, not only to exclude the overlapping spectra, but also, by its variable absorption, to equalise, to some extent, the variable actinic force of the section to be photographed.

Many different dyes answer the purpose, but the following scheme will be found simple and effective for photographing the 2nd order spectrum :—For Sections I. and II., no screen.

For Sections III. to VII., a solution of 1 part of esculin in 2,000 water, with a trace of carbonate of ammonia. For Sections VIII. to XIII., 1 part of aurine in 600 of water.

Some variations of these, however, are of advantage in order to equalise the actinic force. For Section III., 1 of sulphate of quinine in 400 water, with a trace of sulphuric acid. For Section IV., 1 of chloride of copper in 12 of water. For Sections VIII. and IX., 1 of aniline orange in 3,000 of water. Changes in strength may also be made.

In case the overlapping spectrum of the 3rd order has to be photographed, there may be used—For Sections VII. and VIII., 1 of methyl blue in 15,000 of water. For Sections IX. to XIII., 1 of chloride of copper in 3 of water.

Mawson and Swan's lantern and photo-mechanical plates have been found most suitable for the work, on account of their hardness and freedom from grain. They have been employed by the writer for the photography of the spectrum since 1887. For Sections I. and II. they are used as they are. For Sections III. to VI. they are prepared with erythrosine; and for Sections VII. to XIII. they are prepared with cyanin and ammonia.

The erythrosine plates present no difficulties. A bath is prepared of 2½ ounces of water, and 6 minims of 1 erythrosine in 100 water. The plate is first placed in water for one minute, then in the erythrosine bath for one minute, and again in water for one minute. It is afterwards dried slowly in the drying-box.

* The alternative object-glass for use with the violet end of the spectrum is of 38 inches focal length.

The colour of the plate should be almost imperceptible, or otherwise the plate will fog in development.

The preparation of the cyanin plates is based on Schumann's formula as given in Vogel's Manual, published by Gauthier, 1887. A much larger proportion of alcohol is required to keep the plates free from specks of cyanin, a larger proportion of ammonia is necessary to make anything of the extreme red spectrum, and a smaller proportion of cyanin must be used to avoid overcolouring the plates.

For the preparation of the plates, baths are prepared as follows:—

No. 1. 1 oz. methylated alcohol.
35 minims of ammonia (full strength).
1½ ozs. of water.

No. 2. 1 oz. methylated alcohol.
8 minims solution of cyanin, 1 in 500 alcohol.
35 minims ammonia.
1½ ozs. water.

Both baths are brought to a temperature of about 65° Fahrenheit.

The plate is put in No. 1 for 45 seconds, then in No. 2 for 60 seconds, and again in No. 1 for 45 seconds. This treatment keeps the plate of an even colour. The colour of the plates must be almost imperceptible, or they will fog. The best developer is that recommended by the makers for the photo-mechanical plates, with, for the extreme red spectrum, an extra quantity of ammonia. Should the plates show a tendency to fog, a preliminary bath of weak preservative (metabisulphite of potash) for from 20 to 40 seconds is of marked advantage.

Samples of cyanin vary exceedingly. That used as above was obtained through Messrs. Griffin & Co. from a manufacturer in Dublin.

Cyanin plates deteriorate with keeping, especially along the margin. They are at their best for three or four days after preparation, but remain quite fit for use for a fortnight. A better result might be expected, if a good substitute for cyanin could be found that would work without ammonia.

On a bright day the exposures required in the way described are:—For Sections I. to VII., varying up to 2 minutes. For VIII. to XIII., varying from 2 to 20 minutes. For the Low Sun spectrum 2 or 3 times this exposure is necessary.

A set of negatives of the whole spectrum are placed before the meeting. They are not, however, the best negatives selected for enlargement.

Some idea of the minute detail attainable on the negatives may be gathered from an inspection of the negative of No. 1 section under the microscope. The field of view covers about one-eighth of an inch, and in that space over eighty well-defined lines in characteristic groups may be counted. Some of these

lines are spaced 1000 to the inch, and correspond to an angular dispersion of 5 seconds.

This negative, however, is taken on an unprepared plate, and the same minuteness of detail has not been obtained with the plates when dyed. That such definition can be obtained throughout, is shown by some photographs of fragments of the spectrum recently presented to the Society by Mr. Higgs. It is much to be desired that either he or Mr. Ranyard, who has described his work, would state by what photographic process such photographs of the spectrum are obtained.

The photographs are presented to the Society, and will be placed in the Library.

TABLE.

Section of Photograph.		Angle of Grating from Mean Position.	Mean H.S. Altitude.	Mean L.S. Altitude.	Elastic Force of Aqueous Vapour in inches of Mercury.
		° ′	°	°	
I.	H.S.	13 6	44	...	·39
	L.S.	„	...	9	·35
II.	H.S.	14 12	41	...	·35
	L.S.	„	...	7½	·39
III.	H.S.	15 18	44	...	·39
	L.S.	„	...	7	·46
IV.	H.S.	16 24	52	...	·39
	L.S.	„	...	7	·39
V.	H.S.	17 30	55	...	·46
	L.S.	„	...	3½	·26
VI.	H.S.	18 36½	46	...	·24
	L.S.	„	...	3	·37
VII.	H.S.	19 43	46	...	·29
	L.S.	„	...	3	·28
VIII.	H.S.	20 50½	55	...	·30
	L.S.	„	...	5	·37
IX.	H.S.	21 58¼	45	...	·24
	L.S.	„	...	7½	·37
X.	H.S.	23 6¼	46	...	·24
	L.S.	„	...	7½	·30
XI.	H.S.	24 14¼	52	...	·30
	L.S.	„	...	7	·23
XII.	H.S.	25 22¼	47	...	·37
	L.S.	„	...	7½	·26
XIII.	H.S.	26 10	60	...	·30
	L.S.	„	...	7	·20

Photograph of the A line in the Solar Spectrum.

By George Higgs.

(*Communicated by the Secretaries.*)

Where the eye begins to fail in ascending towards the more refrangible portions of the solar spectrum, the properties of the haloid salts of silver enable us to continue the thread of research, and in the opposite direction the photographic limits have from time to time been set back as our knowledge of organic chemistry has advanced, till the distinction between the chemical and thermal has ceased to exist. In spite of this, however, an examination of results seems to point to the fact that photography has been slow in adding to the information hitherto gained by eye-observation of such regions which lie on the less refrangible limits of the visible spectrum.

With a view to formulating some process for preparing dried emulsions which shall give certain and uniform results of a great degree of sensitiveness for this region I have for some time been engaged in investigating the properties, and in the preparation in a state of purity, of some of the salts of the anthracene series, an account of which I hope to furnish in its place (belonging as it does more to the domain of Chemistry than to that of Astronomy).

I herewith beg to submit to the notice of Fellows interested a copy of a portion of "Great A" from my Photographic Map of the Normal Solar Spectrum. In order to show as much detail as possible I have had to enlarge about ten diameters, or three times Ångström's scale. The "head" is seen to be composed of about 50 lines. Each line of the pairs composing the fluting or "tail" is a nebulous double. Between the pairs and commencing at w. l. 7622 are to be seen other pairs which are apparently harmonically related to the thicker nebulous pairs. The same region taken with a low Sun of about 86° to 88° zen. dis. exhibits the head as one broad band, disintegration commencing at w. l. 7595 and 7598·5.

Spectroscopic Notes and Queries.

By the Rev. A. L. Cortie, S.J.

(*Communicated by E. W. Maunder.*)

I. Has D_3 a coincident dark line in the solar spectrum?

The position of this chromospheric line as given by Young in his list of bright lines is w. l. 5874·9. In some of the spectroscopic maps which I have consulted, dark lines are indicated differing by less than one-tenth metre from the position of the bright line. Ångström (1868) draws a telluric line at 5874·2, followed on the less refrangible side by a band of slight intensity terminated by a well-marked line at 5878·3. Fievez (1882),

whose wave-lengths are based on those of Angström, draws a faint double with w. l. 5875·05 and 5874·7, lines which also appear in Piazzi Smyth's Winchester Solar Spectrum (1884). In Thollon's (1890) splendid atlas several faint lines, apparently of solar origin, are drawn near this position. It will have been remarked that one of the lines drawn by Fievez and Piazzi Smyth differs by only two-tenths of a tenth metre from the position assigned by Young to the chromospheric line. This line also appears on some wonderful photographs of this region of the solar spectrum which I have lately received through the kindness of Mr. Higgs, and which will be referred to later more in detail. The other line, drawn at 5875·05, is photographed as a double. The wave-lengths on the photographs are, of the single 5875·9, and of the double 5876·5, the standard chosen being Mr. Louis Bell's value for the wave-length of D_2, 5890·188, which exceeds by 1·21-tenth metres the number of D_2 on Angström's map. It would appear, then, from a mere examination of these maps that D_3 is exceedingly close to, if not coincident with, a dark line on the solar spectrum.

Trouvelot would make D_3 coincident with a dark line, evidently from his drawing the ray 5874·7 of Fievez, or 5875·9 of the photographs. This drawing occurs in the plate which accompanies his paper, "Sur la structure intime de l'enveloppe solaire" (Bull. Astron. 1885). He remarks: "On a quelquefois affirmé que le spectre normal du Soleil ne contient aucune raie noire correspondant à la raie brillante D_3 du spectre de la chromosphère et des protubérances . . . Ceci est une erreur des plus grandes, car cette raie existe, et, bien qu'elle soit excessivement fine et peut-être variable, il n'y a guère de jours où elle ne soit visible dans notre instrument." Further on he speaks of this line as possessing "la finesse extrême."

These observations would appear to be at variance with those of l'abbé Spée, who, in his paper "Sur la raie dite de l'Helium (Bull. de l'Académie Royale de Belgique, 2^{me} série, tome lxix., No. 5, 1880), writes as follows:—"Dans la région correspondante du spectre, il ne se trouve aucune raie obscure. Huggins, dit à la vérité, avoir vu quelquefois à cette place une légère ligne noire, indice d'un renversement partiel, mais ce phénomène n'a jamais été constaté par les spectroscopistes italiens, et le beau ciel de Rome, l'atmosphère si pure et si transparente de la Sicile, sont, pour ce genre d'observations, des garanties de succès que l'éminent physicien anglais a pu difficilement égaler." Unfortunately he gives no reference to Huggins's paper, so that the opinion of this observer, with regard to the point at issue, cannot be quoted here. But Young would seem to lean to the view that the bright line has ordinarily no corresponding absorption ray. Speaking of an observation of the reversal of D_3 as a dark shade over a sun-spot on September 22, 1870 ("The Sun," ed. 1882, p. 130), he thus writes: "It will

be noticed that . . . . the helium-line D_3, which usually is invisible on the solar surface. . . ."

These discrepancies might be explained if the line in the solar spectrum, with which, according to Trouvelot, D_3 coincides, and which at least is extremely near to it in position, were due to the absorption exercised by our atmosphere. In passing it may be noted as an analogous case that the atmospheric double 5990·01 would also seem to be in close proximity to a bright line in Young's list. Ångström has no solar line on his map nearer to D_3 than the iron line at 5883·03, and he marks 5874·2, the line in question, as an air line. Nor has Cornu drawn any solar line in this region of the spectrum. My own observations taken at Stonyhurst with the Browning automatic spectroscope attached to the 8-inch equatoreal, and in which a dispersion of twelve prisms of 60° was employed, also point to the line being atmospheric. On March 17, 1887, it was not visible, the definition being very good, and the Sun near the meridian. The same was the case at noon on a day in June 1888, when the sky being hazy the definition was only fair. But the line was well seen at 6.15 P.M. on May 28, 1887, when the definition was excellent, twelve other lines also being observed between it and D_2. Three days later, the definition being fair and the sky hazy, these lines about D_3 were all visible at 1.45 P.M., but very much less dark than on the 28th when the Sun was low. The photographs of Mr. Higgs entirely corroborate these observations. They were taken with a Rowland concave grating of 14,438 lines to the inch, and represent the D lines and adjoining portions of the spectrum in a high, intermediate, and low Sun. In the high-sun picture, taken at 2 P.M. on August 17, 1890, the lines about D_3 are just traceable as very faint lines. About twenty lines have been photographed between D_2 and the wave-length in question. In the intermediate-sun picture, taken on September 10, 1889, at 7.30 A.M., the lines about D_3 are much darker, and the total number has increased to about thirty. In the magnificent low-sun photograph, taken on August 30, 1890, at 5.35 A.M., the lines about D_3 are quite conspicuous, being almost as dark as the iron line at 5883·03 of Ångström's map. The total number of lines is now more than fifty. These three photographs alone would lead us to conclude that the line with which D_3 is supposed to be coincident is not of solar origin. But in order to remove all possible doubt, Mr. Higgs photographed, at the end of last October, the E and W limbs of the Sun on two contiguous strips. In this photograph all the lines of solar origin are displaced owing to the Sun's rotation, the air lines remaining unaltered in position. The lines near D_3 are not displaced, being thus proved to be due to our atmosphere. The solar lines nearest to D_3 are a faint pair at 5873·5, and a faint line at 5878, the latter line being the least refrangible of a triplet of which the two other components are air lines. These last two lines are

not visible in the high-sun photograph, and just traceable in that of the intermediate Sun. I would, in passing, allude to a few interesting details which are shown on this last photograph. Thus the strong iron line 5883·03 (Ångström) can be distinctly doubled in one strip, but is shown as a single in the other. No ordinary dispersion would ever have shown that this line is not common to iron and our atmosphere. In one strip the nickel line is widely separated from an air line slightly less refrangible, but almost coincides with it in the other. The mean of five measures made with the Hilger micrometer-microscope by Father Sidgreaves at Stonyhurst gives ·066 mm. as the value for the double displacement corresponding to a velocity for each limb of 1·4 miles per second.

With regard to the coincidence of D_3 with the dark air line as observed by Trouvelot, I would incline to the view that insufficiency of dispersion or displacements in the bright chromospheric line rendered the lines apparently coincident, but that they are really separated by a minute difference of position. The following are a few details of observations taken at Stonyhurst with regard to this point.

March 17, 1887. Time 11.15 A.M.—Definition very good. No dark line seen coincident with D_3.

May 28, 1887. Time 5.30.—Definition very good. Sky slightly hazy. D_3 appeared to be between the close double, but certainly more refrangible than the less refrangible of the pair. Observation very difficult.

Later, 6.15 P.M.—Definition excellent. D_3 certainly between the two lines, and distant by estimation two-thirds of the interval between the dark lines from the less refrangible of the pair.

June 2, 1888, time 12 P.M.—Definition fair. Sky hazy. No line seen coincident with D_3.

September 15, 1890.—D_3 very bright in a small prominence. No black line could be detected coincident with the bright line. Definition fair. Time 12.30 P.M.

September 18, 1890, time 2 P.M.—Definition good. The line at 5875·05 was much blacker and sharper than 5874·7. The latter line was extremely faint and rather fuzzy in appearance. D_3 seemed so close that I could not be absolutely certain that it was not coincident with the less refrangible side of the faint line.

Observations were taken on October 27, 1890, by Father Sidgreaves and Mr. W. McKeon, at 11.30 A.M., and again at 2.40 P.M., with both the Browning automatic and the Hilger direct-vision spectroscopes. The observations were very carefully made by each observer, and with the same result. "No trace of a dark line in perfect coincidence with D_3. Line to the left well defined (i.e. 5875·05 Fievez); to the right no line observed but a kind of hazy band, the space between, and in perfect coincidence with D_3, being intensely bright and without any dark line."

So far, then, as we are warranted by the observations discussed in the present paper, we may conclude:

(1) That D_3 has been seen as dark in a sun-spot.

(2) That there is a faint dark line in the solar spectrum, at least within two-tenths of a tenth metre from the bright line.

(3) That this line is due to our atmosphere.

(4) That observers are disagreed as to whether the dark and bright lines coincide in position.

II. The line Ångström 6676·9.

In the memoir which accompanies the late M. Thollon's recently published exquisite maps of the solar spectrum, the author calls attention to the ray 6676·8 (·9 as it is given in Ångström's catalogue), remarking that it is an interesting fact that this line, one of the feeblest on Ångström's map, is now the strongest in the region B—C. He further identifies the line with 641 of Kirchhoff's map, states that its origin is due to iron, and says that it is often seen in the spectrum of the chromosphere and prominences. He also quotes the authority of M. Dunér in corroboration of his remarks, and reports that the latter spectroscopist considers the line variable, and as varying in intensity with the state of solar activity. I propose to examine the statements of the lamented spectroscopist, as to the identification of the line with Kirchhoff, as to its origin, its coincidence with a bright line in the chromosphere, and as to its variability.

The third point may be passed over at once, as Young gives the line in his list as having a frequency of 25, and a brilliancy of 50 (C = 100, 100), and in the maximum period of solar activity it was frequently seen bright at Stonyhurst.

The first, second, and fourth points are more doubtful. Young in his list of chromospheric lines identifies the line with K 654·3, and at Stonyhurst the line was, when first seen bright in the chromosphere, independently identified as corresponding to this number of Kirchhoff's scale. In the catalogue issued by the British Association in 1878 the corrected w. l. is given as 6677·6, and here also the line is identified with K 654·3. On Kirchhoff's map both 654·3 and 641·0 have an equal intensity and width.

Next, as to the origin of the line. Is it an iron line? In Young's list it is attributed to this element, and also as possibly coincident with a line of barium. But neither in Ångström's map, nor in the catalogues of the spectra of the metals published by the British Association, is there any iron line given in this position. But a barium line is given on the authority of Liveing and Dewar at 6677. At least K 641 is not due to iron, but on the authority of the British Association Catalogue to calcium. The nearest iron line is at 6663·1.

Lastly, as to the variability of the line with the activity of the Sun. Examining such maps and catalogues as I have had access to, the following is the result of the comparison:—Kirchhoff (1861) draws the line as one of the strongest in the region B—C, in Ångström's map (1868) it is one of the faintest. Burton (British Association Catalogue, 1878) makes it one of

the most intense in this region; it is one of the strongest in the map of Fievez (1883), and also in all three strips of the Winchester Solar Spectrum of Piazzi Smyth (1884). Finally, Thollon (1890) draws it as the strongest in this region. It would seem, then, that further evidence is required before we can conclude that the line is really variable, for all authorities except Ångström agree in making the line a strong line.

III. The line Angström 6361·16.

In the Philosophical Transactions of the Royal Society, 1873, No. 163, Part 1, in a paper "On Spectrum-Analysis in connexion with the Spectrum of the Sun," Mr Lockyer gives a long line of zinc at w. l. 6362·5, and remarks, "This line was in the Sun in Kirchhoff's time, but has now dropped out; its number on Kirchhoff's map is 771·7." Turning to the British Association Catalogue for 1878, the observations for which were made by the late Mr. Burton, we find K 771·8 identified with w. l. 6361·41, and its origin attributed to zinc. The number 6361·41 has been obtained from the w. l. 6361·16 as given in Ångström's catalogue by applying the correction indicated at p. 29 of his memoir. Burton places the line among the faint lines of the solar spectrum, and it is also drawn as a faint line on Ångström's map. It was therefore to be seen on the Sun in 1861, 1868, and 1878. I have observed the line as widened in Sun-spots five times in 1884, and twice in 1889, and I have no evidence of my own to show that the line was not to be seen in intermediate years.

Note on the Sun-spots of 1888. By E. W. Maunder.

The sun-spots of 1888 were by no means so interesting as those of 1889, for they did not present those strong indications of reviving energy which were seen in the latter year. I have, however, thought that it might possibly be worth while to give year by year some such summary of sun-spot phenomena as I attempted in the paper I read at the April meeting of the Society; and as in this case it would be desirable to do so, not only for future years in their turn, but also for the past years of the Greenwich record, I have commenced with 1888, hoping to follow it with similar notes for the years 1882 to 1887.

Before taking the spots of 1888 I should like to make a slight addition to what I said before concerning the spots of 1889, with the view of strengthening the opinion I then expressed, that the great spot of June 16, 1889, marked the commencement of the new cycle. This may be seen most clearly by dividing the year into two portions: viz., January 1 to June 15, and June 16 to December 31. The latter portion of the year may likewise be further divided into two divisions, the first division including the spots within 10° degrees of the equator, which for the most part may be considered to represent the last efforts of

the old cycle; and the second, the spots distant 20° or more from the equator, which certainly belong to the new cycle, and are its earliest indications. The following table will show strikingly how distinct was the revival both in the mean area of the spots and in their mean distance from the equator after the first half of the year was passed:—

	Mean Daily Spotted Area.	Mean Distance from Equator of all Spots.
		°
1886	381	10·38
1887	179	8·44
1888	89	7·39
1889, Jan. 1 to June 15	18	5·03
1889, June 16 to Dec. 31	130	12·37

If we separate the spots of the last period into two divisions as suggested above, the distinctness of the zone occupied by the spots of the new cycle comes out very clearly:—

Sun-spots from 1889, *June* 16, *to December* 31.

	Mean Daily Spotted Area.	Mean Distance from Equator of all Spots.
		°
Equatorial zone	82	6·59
High latitudes	48	22·41

The increase in area and latitude shown in the equatorial zone in this latter portion of 1889, as compared with the former, was due entirely to one group—the group first seen on June 16—which in its three distinct appearances contributed more than 41 per cent. of the total spotted area of the year. From its position, since it lay in the equatorial zone, this group ought to be reckoned as belonging to the expiring cycle; from its extent and importance, and from the manner in which its appearance was followed by outbursts in the higher latitudes, it may well be reckoned as the first group of the new series.

The duration of the latter groups of 1889 was considerably greater than of the earlier, thus affording a further reason for considering June to be the turning-point. Up to June 15 the mean duration was $7\frac{1}{2}$ days; after June 15 it was 13 days. The number of spot-groups also showed an increase in the latter part of the year. Up to June 15, 10 groups were observed, or, deducting for one reappearance, 9; after June 15 there were 22 groups, or, deducting for reappearances, 17.

Associated with the duration of the groups is their total and mean daily area per group. The mean daily area of a group in 1888 averaged higher than in 1889; but, the lifetime of a group being so much shorter, the total area per group during the entire period of observation was lower in the former year.

	Mean Daily Area per Group.	Total Area per Group.
1888	210	592
1889	140	878
1889, Jan. 1 to June 15	55	294
„ June 16 to Dec. 31	171	1143

This comparison, like the former ones, shows a great increase in energy during the latter part of 1889.

Turning to the sun-spots of 1888, I have already mentioned three features which they presented, in my April paper (*Monthly Notices*, Vol. l., No. 6, p. 361). First, that several characteristics showed that the solar cycle had nearly, but not quite, run out in 1888; for, though that year was inferior to 1887 both as to the number of spot-groups and as to the mean daily area, and presented also a higher number of days without spots, yet in all these three points it had the advantage over 1889, and especially over the first half of it. Secondly, the mean latitude was lower than for 1887; and, thirdly, the average life of a spot was shorter, whilst, as has just been stated, 1889 on the whole, and especially in its latter half, was superior in these points to 1888. The place, therefore, of 1888 in the cycle is very clearly defined. It came almost at the very end, but the actual termination of the old cycle and the beginning of the new one was reserved for 1889. One indication, and one indication alone, was afforded of the coming revival. A very small spot was seen on one day only, in a latitude far outside the zone proper to a period of decline. On December 30 a spot of area 7 was seen in Lat. $-35°{\cdot}5$, 20° further from the equator than any other spot of the year.

Localities of Formation and Dissolution.

Out of the fifty-four separate groups of the year, there were only two cases of reappearance in a second rotation, and in only one of these cases was the group seen a third time. In both instances the formation and dissolution took place in the visible hemisphere. There were thus fifty-one separate groups in 1888. It should be added, however, that two groups had been seen in earlier rotations which fell in 1887. Thus group 2029 of January 1888 had been seen a month earlier in December 1887, and group 2026 was the third appearance of the group which had been seen in 1887 as groups 2017 and 2021.

Of the fifty-one separate groups of the year, thirty formed and dissolved in the visible hemisphere and were seen only in one rotation, ten of these being seen only on one day. Two formed and dissolved in the visible hemisphere, but were seen in more than one rotation; five formed on this side of the Sun, but were dissipated on the other; eight formed on the other side, but were dissipated on this, one of the eight being seen during more than one rotation: and six of which five were seen only in one

rotation, but the sixth in three, formed and dissolved in the unseen hemisphere. The following table shows how 1888 compares with 1889 in this respect:—

	1888.	1889.
Unseen hemisphere—formations	14	3
„ dissolutions	11	4
Visible hemisphere—formations	37	23
„ dissolutions	40	22

Disregarding spots seen only in the visible hemisphere:—

	1888.	1889.
Visible hemisphere—formations	6	5
„ dissolutions	10	4

The unseen hemisphere, therefore, was decidedly the more prolific of spots of sufficient duration to belong to both hemispheres, whereas in 1889 the balance was the other way.

A very striking difference between 1888 and 1889 is seen when the spotted area of each lune of 13°·2 is taken:—

Lune or Day.	Formations.	Dissolutions.	Ephemeral Spots.	Total Area.
First	0	1	0	1943
Second	5	1	1	2736
Third	3	4	1	3718
Fourth	4	3	2	3728
Fifth	2	2	0	3202
Sixth	3	2	2	2806
Seventh	4	3	0	2663
Eighth	1	3	0	2470
Ninth	1	0	0	2148
Tenth	2	2	4	2333
Eleventh	1	4	0	2291
Twelfth	0	5	0	1837
Thirteenth	1	0	0	862

It will be remarked that, whilst in 1889 there was a steady increase in the spotted area from the east limb of the Sun to the western, in 1888 the case was almost reversed. The maximum area was attained at the third and fourth days, and there was a rapid and fairly regular decline afterwards. The formations, as in 1889, were much more numerous to the east of the central meridian, but, including the "ephemeral" spots, or spots seen only on one day, the dissolutions also were slightly more numerous in the eastern quadrant, whereas in 1889 they had been most frequent in the western.

Distribution in Longitude.

1888 did not afford such an extreme example of concentration of energy in one district as was afforded by the great group of June 16, 1889, but the spotted area was by no means evenly distributed. The most prolific district was that, the centre of which lay in Long. 275° and Lat. −7°. On four distinct occasions a considerable outbreak occupied this region, but in no case did the group return a second time. Group 2052 was the largest group of the year; group 2066, the third in size: but the latter group appeared four rotations later than the former. That the disturbed district was the same was, however, shown by two shortlived and much smaller formations, which were seen in the intermediate rotations. This district embraced 28·4 per cent. of the entire spot-area of the year.

Three other localities contributed about 11 per cent. apiece. Of these one, and the most interesting, had its centre at Long. 298° and Lat. −5°; seven groups, one of them the most permanent of the year, appearing in this district. Throughout 80° of the Sun's circumference the only spots observed lay in one or other of these two districts—*i.e.*, either close to Long. 275°, or close to Long. 298°. Another had its centre in Long. 163°, Lat. −12° Four groups were seen here, two of them large, with an interval of three rotations between the two outbursts. The stability of the centre of disturbance in these three districts, of which I have given the positions, is very remarkable when contrasted with the intermittent character of the actual spot-formations, and the same thing was seen on a minor scale in several other regions. The three districts together comprised more than half the spotted area of the year, and formed the locale of fifteen out of the fifty-one separate groups; yet only in one case was an outbreak sufficiently vigorous to last out a complete rotation.

Note on the Spot-group of 1890 *August* 25–*September* 5.
By E. W. Maunder.

A fine group of sun-spots appeared on the east limb of the Sun on August 25 last. This was the second appearance of the group, which had been observed during the preceding rotation, and it was also seen again during the rotation following, its formation and dissolution taking place in the invisible hemisphere. It was at its second appearance that it attained its greatest size and beauty of detail, and it was at this time that it afforded a threefold example of an apparent rotation round each other of pairs of nuclei, which seemed to me sufficiently well marked to justify a record.

As the group drew away from the east limb it first showed itself, on August 26, as composed of three principal spots. The

following day it had greatly enlarged. Two spots, each of area about 50 millionths, led; then came a confused crowd of small faint spots, and, lastly, a large spot of area about 300, with very dark and distinct nuclei, divided into two principal parts—one to the north, a compact well-defined nucleus; the other to the south, less dark and defined, and interrupted by bright bridges. On August 28 the confused crowd of spots in the middle of the group had crystallised out into a number of well-developed spots, one of which, of irregular outline, was much larger than all the others put together. This spot possessed two large dark nuclei.

These three pairs of nuclei, the two leaders of August 27, and the double nuclei of the great central and following spots of the group, afforded the instances of apparent partial rotation to which I wish to draw attention.

The positions of the three pairs on the days of observation were as follows:—

Preceding Pair.

	Preceding Spot. Longitude.	Latitude.	*Following Spot.* Longitude.	Latitude.
	°	°	°	°
Aug. 27	45·4	+21·0	43·3	+20·4
28	45·7	+20·9	44·2	+20·5
29	46·1	+20·6	45·3	+20·4
30	46·4	+20·5	45·9	+20·6
31	46·9	+20·4	46·5	+20·1

The two spots had coalesced by September 1.

Central Pair.

	Preceding Nucleus. Longitude.	Latitude.	*Following Nucleus.* Longitude.	Latitude.
	°	°	°	°
Aug. 28	42·1	+21·7	41·0	+21·1
29	42·8	+21·2	42·0	+20·7
30	43·6	+21·1	42·9	+20·4
31	44·2	+21·0	44·3	+20·2
Sept. 1	45·1	+20·8	46·3	+20·2

This spot had coalesced with the combined spots of the preceding pair by September 1.

Following Pair.

	Preceding Nucleus. Longitude.	Latitude.	*Following Nucleus.* Longitude.	Latitude.
	°	°	°	°
Aug. 27	35·3	+21·9	35·1	+22·7
28	34·7	+21·9	34·3	+22·6
29	34·2	+21·8	33·7	+22·4
30	33·8	+22·0	33·2	+22·4
31	33·7	+22·1	33·0	+22·4
Sept. 1	33·7	+22·0	32·8	+22·2

The two nuclei were in contact on September 1, and were re-divided later, but in a different manner, by several bright bridges. The axial line of the entire spot continued to move further round on September 2 and 3, in the same direction as before. No photograph of the Sun was taken at Greenwich on September 4.

The following table gives the heliographic position of the "centre of gravity" of the entire group during its second appearance :—

	Heliographic Longitude.	Heliographic Latitude.	Area of Umbræ.	Area of Whole Spots.
	°	°		
Aug. 25	43·2	+20·5	21	66
26	40·6	+20·9	35	71
27	38·1	+21·6	82	535
28	37·9	+21·4	107	724
29	37·7	+20·9	123	850
30	38·4	+21·5	131	867
31	38·6	+21·6	126	901
Sept. 1	39·5	+21·3	155	871
2	40·7	+21·2	119	837
3	42·2	+21·1	97	638
4		No photograph		
5	44·2	+20·7	51	417

The apparent sway of the group, first backward and then forward again, was due to the rapid growth of the great following spot on the first two or three days, succeeded by the development and forward motion of the central spot later on. By September 1 nearly the whole of the group had been absorbed into these two great spots; but, whilst drawing smaller spots towards themselves, they seemed to exercise a steady repulsion on each other, the average speed of separation being $1\frac{1}{4}°$, or nearly 9,000 miles a day, from August 27 to September 3. Though this divergence was due much more to the forward motion of the first spot than to the retrogression of the second, the line joining their centres, which may be termed the axial line of the group, preserved an almost constant inclination of about 9° to the solar equator.

The following table gives the positions and areas of the two spots for each day of observation :—

		Following Spot. Longitude.	Latitude.	Area.	Central Spot. Longitude.	Latitude.	Area.
		°	°		°	°	
Aug.	26	35·5	+21·7	54	—	—	—
	27	35·2	+22·2	299	39·6	+21·3	133
	28	34·5	+22·2	328	41·0	+21·0	232
	29	34·5	+21·9	475	42·0	+20·8	275
	30	33·8	+22·2	459	42·9	+20·8	335
	31	34·0	+22·4	500	44·4	+20·8	274
Sept.	1	33·7	+22·3	394	46·0	+20·4	362
	2	33·6	+22·3	333	46·4	+20·4	446
	3	33·7	+22·5	217	46·9	+20·3	402
	4			No photograph			
	5	32·9	+22·5	66	46·5	+20·3	347

The following table gives the position-angle of the following nucleus of each pair as referred to the preceding nucleus :—

	Preceding Pair.	Central Pair.	Following Pair.
	°	°	°
Aug. 27	106	—	14
28	105	299	30
29	104	302	40
30	78	315	56
31	53	17	67
Sept. 1	—	63	78

The rotation of the first pair was, therefore, in the opposite direction to that of the other two. In all three cases, however, the tendency of the movement was to bring spots from the outside of the group nearer towards its general axial line. The well-known tendency of spot-groups is to stretch themselves out in a straight line, which is generally nearly, but not quite, parallel to the equator. The present examples of seeming rotation are, therefore, more correctly examples of the tendency of all formations within a group to range themselves along the axial line, and of spots right and left of that line to move down towards it.

Blackheath,
November 14, 1890.

J.E. Keeler, del. W.H. Wesley, lith.

JUPITER

1890 Aug. 28d 8h 14m P.S.T. 36 in. Refractor of the Lick Observatory.

The Red Spot on Jupiter. By James E. Keeler, B.A.

As the letter of Mr. A. Stanley Williams, in the *Monthly Notices* of June 13, has doubtless directed the attention of many observers to the red spot on *Jupiter*, we may expect a large number of sketches and drawings which will aid in the discussion of the interesting question asked. I send a drawing of the planet, with this region near the centre of the disc, which was prepared from sketches, micrometer measures, and observations of transits of prominent markings, made with the 36-inch equatoreal of the Lick Observatory on the night of August 28. It has also been compared with photographs of *Jupiter*, made with the same instrument by Professor Holden.

But few observations of *Jupiter* have been made with the large telescope this summer, and I have not seen the dark spot to which Mr. Williams called attention (unless it should happen to be one of those shown in the drawing); but according to my past experience, all minor markings, on reaching the red spot, are pushed to one side and flow around it. The drawing which I send may be useful for comparison with others, and may possibly aid in identifying the spot in the modified form which it has doubtless assumed by this time. Mr. Barnard, who has observed *Jupiter* much more systematically than myself, thought the spot referred to by Mr. Williams was gradually dissipated on reaching the red spot. It may be that in flowing around the sides of the latter, its colour was so altered by compression into the narrower limits of the belts surrounding the spot, that it could no longer be recognised.

The accompanying drawing was made under favourable circumstances with a power of about 400. Mr. Barnard, who has lately made many micrometer measures and other observations of the principal markings with the 12-inch equatoreal, agrees with me in considering the drawing an accurate representation of the surface features of the planet at the time given, and it may therefore, as far as it goes, be taken to represent the observations of us both.

The aspect of *Jupiter* has undergone considerable changes during the past year. The long streamers of the equatorial zone, which last summer were the most characteristic feature of the appearance of the planet, seem to be disappearing, and only imperfect examples of them remain. The equatorial zone itself has lost much of its intense whiteness. One of the most striking features at present is the series of small dark spots on the north red belt. When first seen by Mr. Barnard last April they were black, or at least very dark and round; now they are a very deep red, and somewhat elongated in the direction of the belts. Two of these spots are shown in the drawing. The great red spot is of about the same dimensions as last year, and has still a dark shade at its following end, but the middle is whiter, and the

arrangement of belts in the vicinity of the spot is somewhat different. Small round white spots are to be seen on the southern hemisphere, but they are smaller and less conspicuous than they were last summer. Other less obvious changes need not be referred to here, as many more observations of *Jupiter* will be possible during the present opposition. It would seem, on the whole, that the surface features of *Jupiter* indicate less activity in the internal forces of the planet than was manifest a year ago.

Lick Observatory,
August 31, 1890.

Some Experiments relating to the Photometric Comparison of Points of Light with Objects of Sensible Area. By Edmund J. Spitta.

In November 1887 a paper was read before the Society, "On the Appearances presented by the Satellites of Jupiter during Transit," when attention was directed to the fact that whilst using the wedge-photometer during some experiments and measures upon *Jupiter* connected therewith, an unaccountable loss of light was proved to exist when a point of light, such, for instance, as was exhibited by a satellite, was photometrically compared with an object of sensible area like *Jupiter*. For the past three years or more, at the instigation primarily of Professor Pritchard, a protracted research has been in progress to ascertain the cause or causes of such loss, whether physical or physiological; but the subject having extended itself so much further than was anticipated, it has been found necessary to describe the results under three heads: (1) Those connected with the constant of absorption of the wedge-photometer; (2) The objections to employing such a form of photometer when dealing with objects of sensible area and the means devised to remedy the same; and (3) experiments which show peculiar idiosyncrasies in the photoperceptive faculty of the eye when viewing different-sized areas. The object of this communication is to set forth the experiments connected with the last two divisions of the subject.

The results arrived at concerning the first division were presented to the Society in a paper read in March last, but during the progress of the experiments connected therewith, another source of error was thought possibly to cause the loss of light when comparing a point of light with an area in the wedge-photometer. It was this. A point of light, from its very definition, implies that no sensible portion of a wedge is occupied in its passage, but it requires very little thought to perceive that when an area of sensible dimensions is being dealt with this is by no means the case. Moreover, if the area be considerable, the light emanating from its lateral edges impinges on a different thick-

ness of the glass. To supply a correction under these circumstances was not easy, hence the removal of this possible source of error was arrived at by devising an instrument to which the name of "compound wedge-photometer" has been given, and which consists of two thin wedges of neutral tinted glass, made to slide past one another with a uniform rate of motion. Any amount of density (within certain prescribed limits) can be obtained, although a uniformly absorptive area in all parts of the field is rigidly maintained.*

As it became necessary to obtain the coefficient of absorption of this instrument with great precision for use in the experiments to be immediately related, it should be here mentioned that it was evaluated in the following manner.

Each wedge removed from its cell was separately tested for equality in density by the polarising method which peculiarly lends itself to this operation. Both were considered satisfactory. The glasses were then returned to their respective positions, and the coefficient ascertained by employing a small hole illuminated by light immediately under the control of an Abney photometer. By this arrangement the wedge was evaluated by the same method as that employed in its use, which, it would seem, is more philosophical than to evaluate it by equalising lights and use it by a method depending upon extinctions. The artificial star was placed at a distance of 90 inches, and the initial intensity of its light at first arranged so that a ratio of 1 : 8 employed about a third of the available length of the instrument. The value in magnitude over this portion for each half-inch division was found to be ·86. The initial light was then raised and arranged so as to employ the middle third of the wedge, overlapping a small portion of that previously examined. The value here obtained was ·88 mag. for each half-inch division. The last third similarly treated yielded a coefficient for the same length of ·84. These small differences were attributed to errors of observation rather than to any difference in the absorptive power of the glass, hence the mean (·86 mag.) for each half-inch division was adopted in the experiments which follow.

It was found, however, even with the new method of obtaining the coefficient and the new instrument, that a sensible loss of light occurred when a point of light was compared with an area of known dimensions. It was then decided to conduct a further series of experiments which form the third division of the subject, with holes of different sizes, and to ascertain, if possible, the minimum diameter of image at which this loss of light became sensible.

The holes were measured by a parallel wire micrometer, the value of whose screw was first carefully determined, and their respective diameters are given in the following table. The numbers in the first column are for identification only.

* For further information as to details of construction see "A Compound Wedge-Photometer," *Proc. Roy. Soc.*, vol. xlvii.

of the eye.*† The investigations of Helmholtz, Max Schultze, Henle, Müller,‡ and others, have led very distinctly to the belief that the perceptive faculty of the eye varies very greatly and in ill-defined zones around the fovea, which is by far the most highly sensitive portion of the whole retina. Indeed, Johannes Müller, of Berlin, goes still further, for he states that the perceptive faculty of the eye not only varies in the zones previously mentioned, around the fovea, but even may be said to represent a kind of mosaic, for in the zones themselves it is very unequally diffused. Taking this into consideration then, it became very evident the diameter of the images of these holes upon the retina, or their angular value as seen by the eye, was a most important factor in their capability of perception by the brain. Consequently the diameter of the images of these holes on the retina, when seen with the telescope (of 24·75 inch focus) placed at a distance of 90 inches, with an ocular of magnifying power 46, was computed; the latest value for the focal length of the average eye, viz., ·892 inch, being that employed. The figures obtained are set forth in Table III., side by side with their angular value as seen by the eye:—

Table III.

	Inch.		° ′ ″
Hole No. 1	·000943	Angular value	4
,, 2	·010761	,,	40 15
,, 3	·001141	,,	4
,, 4	·002872	,,	12 16
,, 5	·008206	,,	31 46
,, 6	·017438	,,	1 6 42
,, 7	·005967	,,	23 00
,, 8	·006556	,,	25 18
,, 9	·014272	,,	55 58
,, 10	·020962	,,	1 20 30
,, 11	·028455	,,	1 49 38

The most recent measures of the fovea centralis in a large number of subjects show that the pit is slightly elliptical, the short axis varying from ·00788 to ·01576 inch, the mean being about ·01182, which implies that the limit of acute vision lies

* It is somewhat curious that the macula lutea is absent in the ox.

† It is interesting to convey to the mind an idea how the size of the fovea limits the area of the most acute vision in daily life. It may be gathered from the fact that such an area lies within the prescribed limits of a halfpenny held at a distance of about 74·5 inches, which implies that the angular value for vision of the highest order is contained within an angle of about 40′, as will be seen hereafter.

‡ Max Schultze, article, "Retina," in Stricker's *Handbook of Histology*; Helmholtz, *Handbuch der Phys. Optik*; Henle, *Quain's Anatomy*, and Henle and Meissner's *Bericht*; Müller, see Huxley's *Crayfish*.

within an angle of about 40′. It is very evident, then, from a comparison of these figures with those in Table II., that the probable reason the first four holes behaved as points of light (for the figures varied nearly as the areas) arose from the fact that the images on the retina fell within the prescribed limits of my fovea, and so within my bounds of acute vision; and that the cause of the falling off of the ratio obtained in observation V. was due to the fact that, owing to the angle subtended being greater than 40′, the diameter of the image of that hole was just beginning to exceed the limits of the pit, a small portion of it falling upon a less sensitive portion of the retina. Hence the total magnitude of the sensuous impression conveyed to the sensorium was less in quantity than if the whole image had fallen entirely within the fovea. The same reasoning applies, but more strikingly still, to the ratios in the observations following, the angles subtended being still greater, the images of the holes were correspondingly larger, and consequently the loss more pronounced. I submit, then, that the cause of the loss of light noticed when *Jupiter* was photometrically compared with his satellites was due to the fact that the angular value of the Jovian image with the ocular employed was greater than 40′, and consequently was due to a physiological idiosyncrasy in the perceptive faculty of the eye.*

I am prepared to admit that the consequence of this is far-reaching, for it is evident, to obtain a veritable photometric comparison in such cases, the images of each object under observation must not subtend an angle of more than 40′—in other words, be small enough to fall within the limits of the observer's fovea centralis.

With this explanation in view, it is not difficult to understand the results obtained in the experiments numbered from one to five.

In the first (I.), the angular value of the larger hole, greater than 40′, became still greater by the subsequent magnification, so the falling off in the total amount of the sensuous impression conveyed to the brain for perception might be reasonably expected to follow.

With (II.) it was different. The enlarged images caused no falling off in the ratios, because they were in each case smaller than the prescribed limit of distinct vision.

In the case of (III.) the half image appeared relatively brighter than the whole, because the ratio of the amount of light falling upon my fovea in the second instance bore a greater proportion to the image in that case to that which it did in the first. In other words, a greater proportion of the image fell upon the extra sensitive pit when the eye was looking at the semi-lune to what it did when viewing the entire one.

With respect to the last observation (V.), it is submitted the theory is more supported than before, for the angular value of

* From a careful consideration, the fovea centralis of my own right eye is very slightly below the average diameter.

the brass disc was such that its image just overlapped the limits of my fovea; hence the spotted area gave to the brain a far less conception of light than it should have, which arose from the fact that the most exciting part of the image was withdrawn.

At this juncture a crucial experiment suggested itself. If the loss of light really did depend upon the size of the image on the retina, then even the pronounced loss which occurred in observation VI., table II., would not be felt if the two holes were viewed without any telescope whatever, for it is patent the images of the two holes must fall within the area of my acute vision. This was done and it is not a little satisfactory to state that the ratios came out very approximately in accordance with the figures given in column 7—in other words, the two holes acted as points of light.

It is not without interest also to mention that the probable cause of the great difficulty experienced by many, including myself, in learning the use of the wedge photometer, is explained by much the same reasoning as the loss of light. Nothing but continued practice will enable the observer to hold his eye sufficiently steady to keep the image of the fading star rigidly within the area of his fovea centralis. But it might be argued by those adhering to predilected orthodoxy, that the explanation submitted lacks support in practice, owing to the fact that it is often supposed to be easier to see a point of light by *oblique* or *indirect* vision than with *direct*. But it is needless to point out that such is more apparent than real, for it must not be forgotten that a retina wearies as much as any other part of the human organism, and, although the fact of suddenly employing a fresh, though perhaps a really weaker, portion of the sensitive membrane would for the moment bring about a more patent effect than the further use of the wearied part, still that does not show that the lateral edges of the retina are intrinsically of greater perceptive power than the fovea. To bear this out it is very easy to make the attempt which I had tried when learning the use of the wedge, long before I was engaged upon these experiments, viz. to direct the eye by *indirect* vision to a faint object, allowing the most intense attention to be employed; the advantage is manifest at once in the seeing, when the observer turns his eye upon the object *directly*. There is no comparison.

In conclusion it should be remarked that, although this idiosyncrasy in the subject of physiological optics, which has such an important bearing in photometrical astronomy, in no way affects the comparison of areas *of the same dimensions*, still it equally applies to *any* form of photometer when points of light are photometrically compared with objects of sensible area. And further, that if any law for the falling off of the light with increasing area had been obtained, it would not be of practical value, as it would probably only apply to the individual observer himself.

Ivy House, Clapham Common,
November, 1890.

On some Celestial Photographs recently taken at Sydney Observatory. By H. C. Russell, B.A., F.R.S.

I have recently obtained a large portrait lens by Dallmeyer (No. 8 in D Series), with lenses having a clear aperture of 6 inches, with the object of taking pictures of the southern part of the Milky Way. While waiting for the lens which is to be used in taking photographs of the part of the sky allotted to Sydney by the Paris Conference, the portrait lens has been attached to the mounting of that telescope and used for taking the desired pictures since the end of June. The weather has, however, been unusually wet and cloudy, and the work has been delayed thereby. Up to the present time pictures have been obtained which include all the bright part of the Milky Way from 10 hours to 17 hours R.A. Also of the Nubeculæ Major and Minor of the bright region in *Sagittarius*, including 8 Messier, and of several other parts.

I send with this positives on glass of six of these photographs covering the Milky Way from 10^h to 17^h, and paper prints of the same. It will be noted that the definition is only good over the central parts. Attempts were made by bringing the lenses closer together to improve the definition, but without success, and the lenses have been used in the mounting supplied by the maker. The plates cover $14° \times 10°$.

The exposure after many experiments was fixed at 3 hours, so that stars of 15 or, in some cases, 16 mag. (Herschel) should be included.

In 3 hours also a faint picture of the nebula about η *Argûs* has been obtained. It shows decided indications of structure, and on the south preceding side of η, two parallel wreaths of nebulæ are distinctly curved, which may be faintly seen in the positive and in the silver print now forwarded; in the negative it is much better seen. η itself seems to be in another spiral wreath, and the faint markings taken together suggest a structure something like that of the spiral nebula, H 1173. The photograph is much under-exposed for the purpose of delineating the nebula, and, unfortunately, when the need for an exposure of 4 or 5 hours was discovered, η was too far west to admit of it, and the solution of the question must rest until η is in a more favourable position. It is remarkable how slow this nebula is in fixing its image on the sensitive plate. I have often tried before with other instruments, but always failed to get any trace of the nebulous light on the plate.

In the great dark oval which is shown near the extreme north of Herschel's drawing of the nebula about η *Argûs*, he shows four minute stars of 16th magnitude. In going over his work with a $7\frac{1}{4}$ inch telescope, I saw three of these stars, and in the photograph obtained in 3 hours three are shown in this oval space, which the photograph shows quite void of other light.

The lemniscate also appears quite void of light except the solitary 15th magnitude star which Herschel speaks of. In the negative, and particularly in the silver print, the lemniscate appears in striking contrast to the bright parts surrounding it.

Generally the photograph bears out the details of Herschel's drawing, especially in parts to which he calls attention; where the outline is limited, as it were, by particular stars; but the scale of the photograph is too small to show the details immediately surrounding η itself.

The peculiar features referred to in this nebula are shown in three negatives, and cannot be accidental; and I feel sure that a longer exposure will reveal additional evidence of the spiral character of the nebula.

Turning now to the limits of the Milky Way, as shown by the photographs, it will be seen that they differ very much from those given in the best drawings. For instance, the boundary, as shown by the two methods, is alike between η and θ *Argûs*, but to the north of η it stretches out far beyond the limit given in drawings. It will be seen, also, that the whole of the stars in the Cross are fully involved in the Milky Way, and the Coal Sack, instead of being a closed space is seen to be open on the south side; this is shown in photographs No. 3 and 3*a*. It also appears that stars are very numerous over three-fourths of it, and that it is only in the extreme north of it that we find that absence of stars which would justify the name.

A cluster of small stars will be noted near the solitary 7th mag. star in this space, which are remarkable for their brightness in the photograph compared with what one sees with the telescope. Altogether, a photograph conveys a picture of the Coal Sack very different from the drawings.

When the photographs are put together (see those mounted on one card), the Coal Sack is seen to extend in relatively dark marking towards and north of β *Centauri*, where it terminates in a space which seems to be absolutely void of stars in a number of photographs which have been taken from it. It is small, about half a degree in diameter, and extends in a curved line for about 2° long.; and in relation to this it is remarkable that the great rift in the Milky Way beginning at α *Centauri* does not appear in the photographs. The stars, it is true, are not quite so abundant there if counted, but when looking at the photograph there is little difference, and certainly nothing like the dark space seen when the eye is turned to the sky at that part.

The grouping and clustering of the stars thus shown in the southern part of the Milky Way are intensely interesting, but an idea of the effect cannot be conveyed in words. It must be seen in the pictures themselves in order to get an idea of what it is like.

Certain it is that these pictures present the Milky Way in an entirely new light, quite different from the telescopic or naked-eye view, and give it such a different aspect that the question arises, which are we to accept?

It seems evident that the photograph may be made to present the stars to us under an aspect quite different from that presented to the eye, because, by continued exposure, the faint stars may have time to produce as much effect as brighter stars, because the effect is limited by the amount of silver in the film, which, when altered by the bright star, stops any further effect of that star, while the faint ones may go on piling up their effect.

The negatives of the bright spot in *Sagittarius* and the Nubeculæ Major and Minor have required upwards of four hours' exposure, and contain a mass of detail; but there has not been time to reproduce them. It may be mentioned, however, that comparatively few of the small nebulæ which are to be found in the Nubecula Major will record themselves in four hours.

The plates used for these photographs were *Extra Rapid Ilford*. It will be seen that nearly all of them have stains along, but not parallel to the margins; these are caused by the tissue paper put between the plates in packing. I have found these plates the most rapid in the market here, and have used them although stained at the margins. I hope the Royal Astronomical Society will allow me to present these pictures of the Southern Milky Way to the Library. I think they are the first of their kind taken in the Southern Hemisphere.

Appendix.

In the preceding notes about photographs of the Milky Way, I referred to others which had been taken, and I am now able to send some positives and silver prints from them, and they are, in some respects, more interesting than those already sent, for they reveal details of structure in the Milky Way and more especially in the Nubeculæ Major and Minor of an unexpected character.

In the first place several photographs of Nubecula Major have been taken with gradually increasing exposures. That taken on Sept. 18th was exposed $5^h\ 2^m$, but owing to passing clouds the effective exposure was only $4\frac{1}{2}$ hours. The negative is good but evidently wanted more exposure, and when looking at it I saw nothing of the spiral structure of the whole, which became evident as soon as a silver print was made. In fact, the whole of this great cloud is a complex spiral nebula with two centres, if I may so express it. One of these is midway between 30 Doradûs and the 6th mag. star at R.A. $5^h\ 23^m$, and 158° 48′ N.P.D. An examination of the positive and silver prints will show the spiral arrangement of stars and nebula and a dark band surrounding this space. The other centre is about two degrees north of this and in same R.A.

So far as I am aware the spiral structure of the Nubecula Major is shown for the first time in these photographs. It was not seen on the negatives, the first of which was taken on Sept. 15th. The im-

pression they gave me was, that a still longer exposure was needed to show the details and numerous small nebulæ. But when on Oct. 1st, I had a silver print made of the negative of the 18th Sept. the spiral structure was evident at the first glance and could then be seen in the negatives.

Something of the same form can be seen in Herschel's Chart of this object, although his drawing is very different, and it is remarkable that his drawing of the Nubecula Major is very like what the photograph shows of Nubecula Minor; that is, a form something like the Dumb-bell nebula. And I have no doubt from the appearance of the Nubecula Minor in several photographs, that a longer exposure will reveal it as a great dumb-bell nebula, a form which seems very definitely indicated in the photographs already taken.

That part of the Milky Way which is situated around γ^2 *Sagittarii* has been photographed several times; because the Sydney photographs, while showing many more stars than the reproduction of Mr. Barnard's photograph, which appears in the Royal Astronomical Society's Notices for March 1890, page 312, taken at the Lick Observatory on August 1, 1889, gives at the same time a very different representation of the relative illumination of different parts. The contrasts are much greater in the picture taken at Mount Hamilton than at Sydney, as this contrast seems to be independent of the number of stars on the plate; it is an interesting question what causes it, because, if not due to the method of reproduction, it is of some importance, in the attempt to make a photographic Chart of the Milky Way, to know what causes the difference. Fortunately for the comparison the lens used at Sydney has so nearly the same focal length as that used at Mount Hamilton, that the photographs can readily be compared. I have sent a positive from the negative taken on September 17, 1890, and exposed $4^h\ 27^m$, another positive from a plate taken October 2, 1890, which was exposed for $4^h\ 2^m$, and thirdly, a negative taken on October 1, 1890, and exposed $3^h\ 32^m$. In passing I may call attention to the fact that on this plate, and all others taken with this lens, the stars outside the limit of good definition are shown as crosses, formed by a streak radiating from the centre of the plate, crossed by a curve like a crescent with its back towards the centre of the plate.

It will be observed that these three pictures of the same object taken on different nights, and with varied periods of exposure, give very nearly the same relative intensity of the various parts of the wonderful structure of this part of the Milky Way, and it will be observed, as already stated, that this contrast differs very much from the reproduction of the Mount Hamilton negative already referred to. The very dark part surrounding γ^2 *Sagittarii* in the Mount Hamilton picture is not found in the Sydney one. The question is one of some importance and can only be fairly discussed when the negatives or direct prints from them can be compared. If this negative, taken on October 1 at

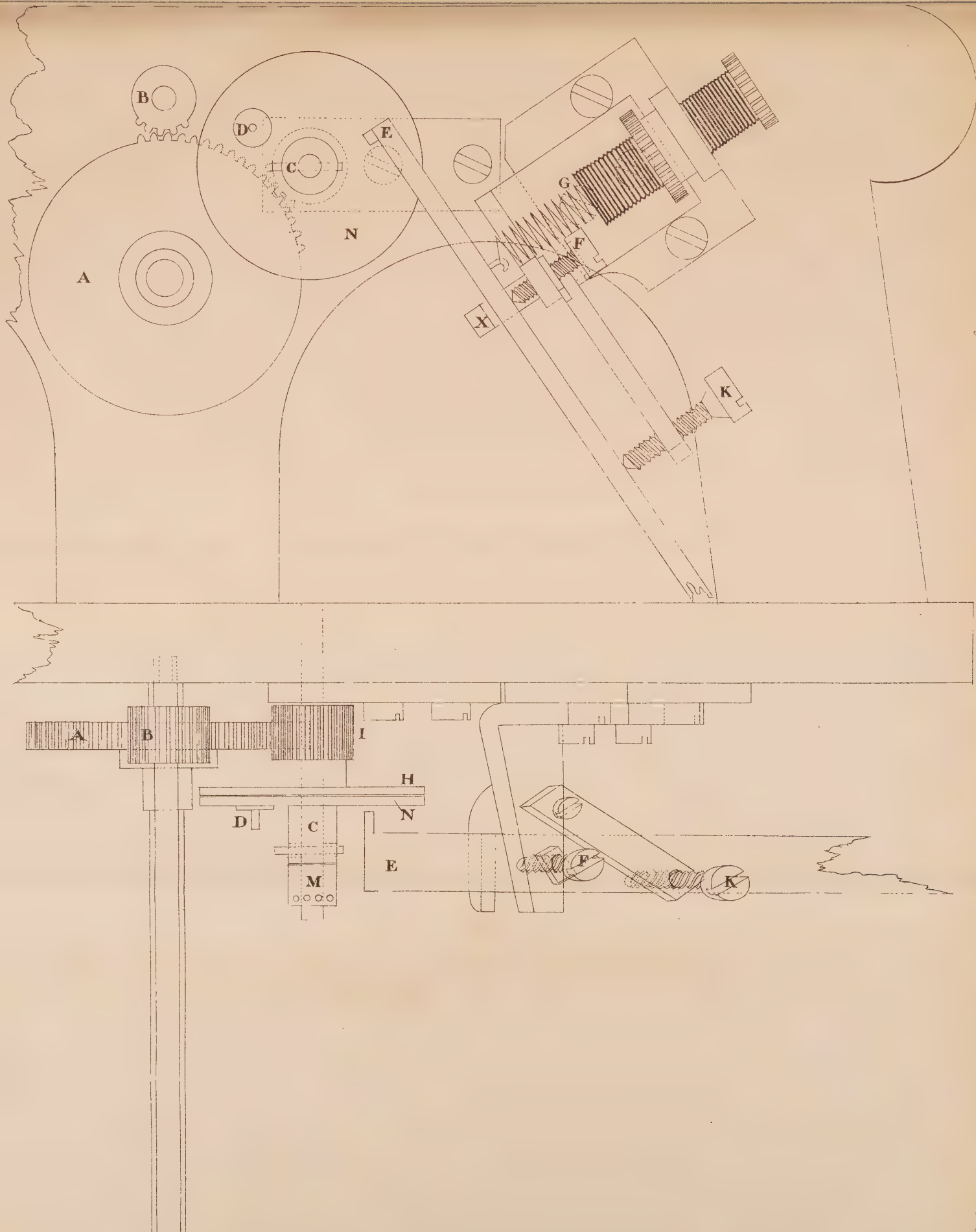

DIAGRAM *showing parts in* ELECTRICAL CONTROL *of observing clock of astro-photographic telescope at Sydney.*

Sydney, be examined by the aid of an eyeglass some of the extraordinary details found in this part of the Milky Way, and which is very unlike what I have found in other parts, will be seen. It seems as if one were looking at curve after curve found, farther and farther back in the infinity beyond, like eddies in an infinitely complex vortex, till they end in faint nebulous points of light; which can only just make themselves known after 4 hours of steady impact on the sensitive film.

It would be impossible to convey in words what the photograph shows of the peculiar structure found in the Milky Way at this part, the general character of the arrangement of the stars here may be said to be in curved lines and ellipses, and is quite different from that found in *Argo*, *Crux*, and *Centaur*.

The photographs are placed in the Library.

On an Electrical Control for driving Clocks.
By H. C. Russell, B.A., F.R.S.

At the present time any method which promises to control driving clocks for photographic telescopes satisfactorily is worth discussion, because the complete solution of the difficulty of getting uniform motion for telescopes is very much to be desired, and I hope this will be sufficient excuse for bringing the following notes before you.

The method about to be described does not profess to give absolutely uniform motion, but it does claim so to correct the motion every second as to prevent any error greater than $\frac{1}{100}$ of a second of time. The two photographs herewith will show the general design of the clock, but since any form of clock would serve the purpose, provided one wheel in its train turned in one second, I need not waste time in describing it; except to say that uniform motion is obtained by using two pendulums, and that this form seems to be peculiarly suited to the method of control, for two reasons—first, because uncontrolled it gives remarkably steady-going; and, secondly, because the pendulums are heavy and are not affected by the momentary stoppage of the driving screw (which is connected with the train by friction) which takes place every second.

In selecting a method of controlling this driving clock, it seemed to me better to have the motion of the clock uniformly gaining and stop the excess every second, rather than have one as nearly uniform as possible and correct it when fast or slow, because in the former method all the wheels and working parts are bearing in one direction, and if the screw is stopped by the control, the train goes on, and takes the screw on with it, the moment it is set free by the action of the control. The minute motion which takes place between the train and the screw each second has surprised me very much; but exhaustive experiments

show conclusively that if the driving clock is gaining one second in 200, or from that to so small a quantity as one in 600, the control will catch it and put it right second by second, provided that the control clock makes its contacts with perfect regularity and that the battery power is sufficient to work the control the instant contact is made. Certainly if it does not correct it the exact amount every second, the faults cannot be detected by the means used in these early experiments.

Referring to the photographs it will be seen on B that the screw S (see also photograph A, letter W), for driving the telescope, has at one end a wheel (W) nine inches in diameter, on the rim of which is a worm which has 240 teeth, and as this is required to turn in four minutes it is worked round by a screw which turns round in one second; on the end of this screw is a disc (N in the diagram), which while it can be forced along it by a screw nut M, to adjust the friction between N and H, it cannot turn round it. On the same screw is another disc (H) of like size attached to the wheel (I, 20 teeth), and, excepting the friction between N and H, free to move round the screw. I has the same number of teeth as B, the axis of which is connected direct to the two pendulum governors, and, like B, is driven by the wheel A. The friction between H and N is sufficient to carry the screw G round, against all the friction of moving the large telescope, of which the moving parts weigh two tons. E is a continuation of the armature of the controlling magnet, and in the position shown in the diagram it catches the pin D, which is fixed to the disc N, and stops it, until the current from the controlling clock pulls E down on to the stop X. So long as D is held, I, and of course H, which is attached to it, go on with A and B, and directly D is released it is carried on by the friction between H and N, as the currents come through the magnet every second, D is released once every second, and stopped if it makes a revolution in less than a second. Now, since the screw working into the 240-worm wheel is rigidly attached to N, it follows that once in every revolution it is exactly correct in time, because it cannot pass E until the signal from the control clock comes; and by adjusting the speed of the driving clock it may be made to turn uniformly each time in a little less than one second, so that the pin D just strikes E as it is pulled down by the control, and it is surprising how small an error in the time of rotation of D can be corrected in this way. Some idea of the linear amount of it may be got from the fact that in its revolution D travels two inches, and if it is moving with a gaining rate of one second in 10 minutes, it will be stopped $\frac{1}{600}$ part of 2 inches each time. As already stated, it works most satisfactorily under such circumstances, and the fact of being able to deal with such a small error shows the advantage of having the correction all one way.

Experience shows that it will be an advantage to put D

farther from the axis, so that it travels each second, say, 6 inches, but the chronograph sheets herewith show how satisfactory it is with present arrangement, particularly when the battery is vigorous. See particularly sheet A, and in sheet B, slight variation due to weakness of battery.

The other parts shown in diagram need little explanation. H serves to adjust the strength of the spring C, which lifts the stopping piece E; F adjusts the amount of lift, and K, when screwed down, puts E out of gear.

Two ordinary bottle bichromate batteries supply the current, and it is found that the mercury and alcohol contact is the most satisfactory, and interferes least with the rate of the controlling clock.

I have confined this description to the essential parts required to control the motion of the screw, which turns in one second, and it will be seen that the clockwork driving this may be of any form. The advantages seem to me to be (1) that one has only to make one accurate wheel, the 240-teeth worm wheel; (2) the convenience of controlling a screw that revolves in one second; (3) when correcting any error all the parts are pressing one way.

Note.—When testing the rate under control, a small point was fixed on the screw R (photograph A), and this made a contact at each revolution.

The photographs of the driving clock are placed in the Library.

On the Orbit of 99 Herculis = Alvan Clark 15. By J. E. Gore.

This close and difficult double star was discovered by the late Mr. Alvan Clark at Mr. Dawes's observatory in 1859. Since that year the distance between the components has diminished, and the object is now a difficult one, even with the great refractor of the Lick Observatory. The recorded measures are few, but as a measure by Mr. Burnham this year shows that the companion has described about 298° of its apparent ellipse since its discovery, I have computed the orbit, and find the following provisional elements:—

$P = 53{\cdot}55$ years.	$\Omega = 50°\ 5'$.
$T = 1885{\cdot}58$.	$\lambda = 110°\ 44'$.
$e = 0{\cdot}7928$.	$a = 1''{\cdot}12$.
$i = 38°\ 37'$	$\mu = +6°{\cdot}7222$.

The following is a comparison between the measures and the positions computed from the above elements:—

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
1859·63	Dawes	347°·1	347°·2	−0°·1	1″·71	1″·63	+0″·08
1878·46	Burnham	24·4	22·6	+1·8	0·99	1·10	−0·11
1879·468	,,	26·5	26·3	+0·2	1·13	1·01	+0·12
1880·455	,,	30·1	30·4	−0·3	0·70	0·92	−0·22
1880·613	,,	33·1	31·3	+1·8	0·90	0·90	0·0
1881·43	,,	29·4	35·7	−6·3	0·51	0·81	−0·30
1888·733	,,	"Single with 36-inch refractor"	273·7	...	...	0·60	...
1889·502	,,	281·2	281·2	0·0	0·65	0·68	−0·03
1890·49	,,	285·1	288·6	−3·5	0·56	0·75	−0·19

According to the above elements the minimum distance between the components occurred about 1885·50, when the position angle was 156°·75 and the distance 0″·18. The angular motion of the companion at that time was at the rate of 114° per annum, or about 1° in 3·15 days!

The primary star was measured 5·21 magnitude at Oxford, and 5·36 at Harvard, and the companion was estimated 10½ to 12 by Burnham.

On the assumption that the combined mass of the components is equal to the mass of the Sun, the "hypothetical parallax" would be

$$\pi = a P^{-\frac{2}{3}} = 0''{\cdot}08.$$

Observations of the Variable Star R Carinæ from November, 1886, to June, 1890. By John Tebbutt.

My last-published observations of this interesting variable are to be found in vol. xlvi. of the *Monthly Notices*, and extend from September, 1883, to April, 1886. The following are all the results which I have obtained since April, 1886, and the comparison stars are the same as employed on previous occasions. In my communication above referred to I assigned 312 days as the approximate period from maximum to maximum. Professor Chandler has since discussed the published observations of this star and has arrived at a period of 312·14 days.

Concluded Magnitude of R. Carinæ.

Date.	Mag.	Date.	Mag.	Date.	Mag.
1886, Nov. 16	6·5	1887, April 1	8·7	1887, June 21	8·7
,, Dec. 18	5·4	,, ,, 8	8·7	,, July 16	8·4
,, ,, 22	5·5	,, ,, 23	9·0	,, Oct. 22	5·4
,, ,, 27	5·5	,, May 9	9·2	,, Dec. 8	6·9
1887, Jan. 14	5·9	,, ,, 24	9·2	,, ,, 17	7·8
,, Mar. 17	8·5	,, June 12	9·1	1888, Jan. 2	8·5

Date.	Mag.	Date.	Mag.	Date.	Mag.
1888, Jan. 20	8·7	1888, Dec. 5	8·6	1889, July 22	5·7
„ „ 31	8·8	„ „ 23	9·0	„ Dec. 13	9·2
„ Feb. 7	8·8	1889, Jan. 5	9·1	„ „ 25	9·2
„ „ 16	9·0	„ „ 22	9·2	1890, Jan. 8	9·2
„ „ 21	9·0	„ „ 28	9·0	„ „ 22	8·7
„ Mar. 3	9·1	„ Feb. 21	9·0	„ Feb. 26	8·5
„ „ 8	9·1	„ Mar. 4	8·8	„ Mar. 15	8·1
„ „ 14	9·2	„ „ 21	8·5	„ April 7	5·8
„ „ 19	9·2	„ April 1	8·4	„ „ 11	5·3
„ „ 28	9·1	„ „ 30	7·8	„ „ 18	5·3
„ April 12	9·0	„ June 3	5·2	„ „ 23	5·5
„ „ 18	9·0	„ „ 7	5·0	„ „ 26	5·5
„ „ 27	9·0	„ „ 13	4·9	„ May 7	5·6
„ May 4	8·9	„ „ 17	4·9	„ „ 8	5·7
„ „ 13	8·7	„ „ 21	4·7	„ „ 13	5·8
„ „ 19	8·6	„ „ 24	4·7	„ „ 19	5·9
„ June 8	8·0	„ „ 29	4·9	„ „ 23	6·1
„ „ 12	8·0	„ July 4	5·0	„ June 11	6·6
„ „ 24	7·9	„ „ 7	5·0	„ „ 20	6·8
„ July 5	7·1	„ „ 14	5·0		

Windsor, N.S. Wales :
September 25, 1890.

Observations of the Solar Eclipse of 1890 *June* 16–17, *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

The observations of this eclipse with the south-east equatoreal were directed to the determination of the corrections to the Moon's R.A. and N.P.D. and to the semi-diameters of the Sun and Moon. The circumstances of this eclipse were, however, not favourable for determination of corrections to the semi-diameters.

Owing to the cloudy weather it was only possible to make a few observations on the morning of June 17; and though an extended programme of five groups of observations had been drawn up, two groups only were represented in the results, and the corrections to the Moon's R.A. and N.P.D. could not be obtained independently of the corrections to semi-diameters. The following measures were made by Mr. Turner, the declination microscopes being read by Mr. Downing :—

Putting :—

$d\alpha$ = correction to Moon's R.A.

$d\delta$ = correction to Moon's N.P.D.

ds = correction to Moon's Semidiameter.

$d\mathrm{A}$ = correction to Sun's R.A.

$d\Delta$ = correction to Sun's N.P.D.

$d\mathrm{S}$ = correction to Sun's Semidiameter.

(1) From $21^h\ 47^m$ to $22^h\ 5^m$ G.M.T., 6 differences of N.P.D. of p and f cusps were observed, giving

$$-\tfrac{1}{4}d\alpha - d\delta + d\mathrm{S} + ds.$$

(2) From $22^h\ 10^m$ to $22^h\ 16^m$ G.M.T., 4 differences of R.A. of p and f cusps were observed giving

$$-d\alpha + d\mathrm{S} + ds.$$

Two resulting equations were found by taking the sums of the constituent equations in each group, obtained by a comparison of the measured with the tabular quantity as affected by the symbolical corrections $d\alpha - d\mathrm{A}$, $d\delta - d\Delta$, ds and $d\mathrm{S}$:—

$$-20''{\cdot}49 = -1{\cdot}294\,(d\alpha - d\mathrm{A}) - 5{\cdot}970\,(d\delta - d\Delta) + 6{\cdot}822\,ds + 6{\cdot}975\,d\mathrm{S}$$
$$-13''{\cdot}69 = -4{\cdot}046 \qquad -0{\cdot}086 \qquad +4{\cdot}452 \qquad +4{\cdot}397$$

The solution of which is :—

$$d\alpha - d\mathrm{A} = +3''{\cdot}326 + 1{\cdot}081\,ds + 1{\cdot}067\,d\mathrm{S}$$
$$d\delta - d\Delta = +2''{\cdot}711 + 0{\cdot}908\,ds + 0{\cdot}937\,d\mathrm{S}.$$

From observations of the Sun made with the transit-circle on 10 days between May 24 and June 28 :—

$$d\mathrm{A} = +0''{\cdot}511 \qquad d\Delta = +0''{\cdot}177$$

Combining this result with that obtained from the equatorial observations during the eclipse, we obtain for the corrections to the tabular place of the Moon in R.A. and N.P.D. :—

$$d\alpha = +3''{\cdot}837 + 1{\cdot}081\,ds + 1{\cdot}067\,d\mathrm{S}$$
$$d\delta = +2''{\cdot}888 + 0{\cdot}908\,ds + 0{\cdot}937\,d\mathrm{S}.$$

From 5 transits of the Sun's diameter and 5 measures of the diameter in N.P.D., made on the morning of June 18, with the same instrument and by the same observers, the apparent corrections to the tabular semidiameter were found to be :—

in R.A. $d\mathrm{S} = -0''{\cdot}03 = -0''{\cdot}41$

in N.P.D. $d\mathrm{S} = +0''{\cdot}11.$

from which it would appear that $d\mathrm{S}$ is a very small quantity.

The telescope of the South-East Equatoreal has an aperture of 12·8 inches, and a magnifying power of 295 was used.

Royal Observatory, Greenwich :
1890 *November* 13.

Observations of Comet a 1890 (*Brooks*) *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

The observations were made with the East or Sheepshanks Equatorial, aperture 6·7 inches, by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power 60.

Comet a 1890 (*Brooks*).

Greenwich Mean Solar Time.	Observer.	✓−✶ R.A.	Corr. for Refraction.	✓−✶ N.P.D.	Corr. for Refraction.	No. of Comp.	Apparent R.A.	Log. factor of Parallax.	Apparent N.P.D.	Log. factor of Parallax.	Comp. Star.
d h m s		m s	s	″	″		h m s		° ′ ″		
Sept. 14 8 22 58	A. D.	+1 8·8	0·0	+ 5 54·0	+0·6	6	...	9·6246	...	0·8162	*a*
8 33 57	,,	+5 43·7	0·0	+ 9 17·7	+1·4	3	13 0 53·9	9·6145	57 46 53·9	0·8251	*b*
8 33 57	,,	+5 17·0	0·0	− 0 29·7	−0·1	3	13 0 57·0	9·6145	57 46 49·4	0·8251	*c*
15 8 3 30	L.	−0 2·5	0·0	+ 2 30·4	+0·2	3	...	9·6298	...	0·8065	*d*
8 27 16	,,	+1 1·6	0·0	+ 0 24·2	0·0	6	...	9·6176	...	0·8229	*e*
8 48 2	,,	+5 23·7	0·0	+11 15·7	+1·6	3	13 1 3·7	9·6055	57 58 36·7	0·8392	*f*
8 48 2	,,	+4 52·3	0·0	− 3 4·3	−0·6	3	...	9·6055	...	0·8392	*g*

Assumed Mean Places of Comparison Stars.

	Star's Name.	R.A. 1890·0.	N.P.D. 1890·0.	Authority.
		h m s	° ′ ″	
a	B.D. + 32°, No. 2317	12 59 40	57 41	Bonn Observations, vol. iv.
b	W.B. (2) XII. 1066	12 55 10·43	57 37 37·5	Washington Catalogue, 1860.
c	W.B. (2) XII. 1077	12 55 40·16	57 47 21·9	Weisse's Bessel (2).
d	Anonymous			
e	B.D. + 32°, No. 2319	13 0 1	57 59	Bonn Observations, vol. iv.
f	W.B. (2) XII. 1077	12 55 40·16	57 47 21·9	Weisse's Bessel (2).
g	B.D. + 32°, No. 2313	12 56 12	58 3	Bonn Observations, vol. iv.

Notes.

September 14.—Comet a faint patch of light with distinct stellar nucleus, but difficult to observe.

The observations are corrected for refraction, but not for parallax.

The initials A.D. and L. are those of Mr. Downing and Mr. Lewis respectively.

Observations of Comets made at the Orwell Park Observatory in the years 1889–90. By J. I. Plummer, M.A.

Comet I. 1889 . . . (*Barnard's, Sept.* 2, 1888.)

Date. 1889.	Greenwich Mean Time.	Comet − Star. $\Delta\alpha$.	Comet − Star. $\Delta\delta$.	No. of Comps.	Comet's App. R.A.	Log $(p\times\Delta)$.	Comet's App. Dec.	Log $(p\times\Delta)$.	Red. to App. Place.		Comp. Star.
	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Feb. 8	6 35 8	+1 8·43	− 2 41·8	5–6	23 42 48·72	9·5137	− 4 34 6·2	0·8523	−1·64	−10·8	1
June 3	13 23 25	−1 6·12	+ 2 15·0	6–6	22 50 57·68	−9·5285	+ 2 40 22·6	0·8350	+0·28	− 1·0	2
19	11 46 28	+2 44·06	+ 3 47·0	8–8	22 17 12·84	−9·5286	+ 2 17 23·9	0·8361	+0·99	+ 1·1	3
25	12 15 27	−0 23·99	− 1 2·7	8–8	22 0 37·62	−9·4501	+ 1 52 59·8	0·8342	+1·23	+ 3·9	4
26	11 44 16	−3 17·86	− 5 56·6	8–8	21 57 43·78	−9·4840	+ 1 48 6·2	0·8354	+1·26	+ 4·2	4
27	12 1 45	+2 49·43	− 2 8·4	8–8	21 54 41·14	−9·4500	+ 1 42 45·1	0·8348	+1·33	+ 4·4	5
July 1	11 29 43	−2 16·79	+ 4 1·2	7–7	21 42 9·50	−9·4556	+ 1 19 23·2	0·8366	+1·47	+ 5·3	6
22	11 10 2	+2 14·71	+ 2 35·0	7–7	20 27 29·04	−9·0329	− 1 48 16·0	0·8514	+2·07	+ 8·7	7

Remarks.

February 8.—Comet faint from moonlight. The wind being very high, the clock was heard with difficulty.
June 3.—The last comparison is rather doubtful, the comet having become faint with the dawn.
June 26.—The intermediate comparisons are rather doubtful, the sky hazy, and even cloudy, at this time.
July 22.—Observations discontinued after this day, the declination axis having become immovable. Resumed on August 29.

Comet V, 1888 . . . (*Barnard's, Oct.* 30, 1888.)

Date. 1889.	Greenwich Mean Time.	Comet − Star. $\Delta\alpha$.	Comet − Star. $\Delta\delta$.	No. of Comps.	Comet's App. R.A.	Log $(p\times\Delta)$.	Comet's App. Dec.	Log $(p\times\Delta)$.	Red. to App. Place.		Comp. Star.
	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Mar. 25	8 54 46	+1 28·81	+ 9 14·8	7–7	9 20 58·60	−8·1550	+36 20 14·8	0·3733	+0·62	+ 1·6	8

Remarks.

March 25.—Comet very faint and difficult to observe, partly owing to the impossibility of excluding all artificial light from the eye.

Comet IV. 1889 . . . (*Davidson's, July* 19, 1889.)

Date. 1889.	Greenwich Mean Time. h m s	Comet—Star. Δα m s	Comet—Star. Δδ ′ ″	No. of Comps.	Comet's App. R.A. h m s	Log. ($p \times \Delta$)	Comet's App. Dec. ° ′ ″	Log. ($p \times \Delta$)	Red. to App. Place. s	Red. to App. Place. ″	Comp. Star.
Aug. 29	9 10 1	+0 28·58	− 1 53·4	8–8	16 11 47·06	9·5103	+24 31 30·6	0·6978	+0·80	+12·5	9
30	9 54 41	−1 23·48	+ 5 26·1	7–7	16 14 11·55	9·5630	+24 57 49·2	0·7278	+0·80	+12·7	10
Sept. 1	9 47 48	+1 18·93	− 2 0·8	8–8	16 18 44·04	9·5628	+25 45 8·2	0·7194	+0·76	+12·9	11
6	9 50 32	−2 28·50	+ 2 45·0	1–1	16 29 30·49	9·5788	+27 26 27·4	0·7165	+0·73	+13·7	12
8	9 59 12	+2 21·09	− 5 28·9	6–6	16 33 38·72	9·5901	+28 0 40·6	0·7229	+0·68	+13·8	13
16	8 7 1	+2 58·28	− 6 7·6	8–8	16 49 17·90	9·4844	+29 53 53·9	0·6181	+0·57	+14·5	14
17	8 50 58	+1 21·84	+ 5 9·7	8–8	16 51 17·04	9·5529	+30 6 28·5	0·6591	+0·57	+14·6	15
18	8 19 2	−1 21·10	+ 0 7·8	8–8	16 53 9·59	9·5131	+30 17 34·6	0·6281	+0·57	+14·7	16
22	9 12 26	−1 49·83	− 9 30·2	8–8	17 0 49·74	9·5889	+31 1 1·9	0·6820	+0·51	+15·0	17
25	7 52 12	+2 36·03	+ 8 22·6	8–8	17 6 23·44	9·4978	+31 29 42·5	0·6014	+0·45	+14·9	18
30	8 33 11	−2 2·61	+ 7 43·5	9–9	17 15 53·19	9·5726	+32 13 33·1	0·6465	+0·41	+15·3	19
Oct. 3	8 32 43	−0 57·86	+ 0 27·5	9–9	17 21 34·42	9·5804	+32 37 15·8	0·6488	+0·36	+15·4	20
12	7 17 17	−3 29·83	− 5 55·3	8–8	17 38 36·62	9·5080	+33 41 25·1	0·5717	+0·26	+15·8	21
14	6 50 49	+3 4·12	− 5 19·0	7–7	17 42 25·72	9·4662	+33 54 41·5	0·5433	+0·20	+15·4	22
18	7 48 56	+1 59·49	+ 6 54·0	7–7	17 50 15·52	9·5743	+34 21 1·7	0·6146	+0·16	+15·4	23
19	7 42 5	+1 30·78	− 0 6·7	8–8	17 52 12·76	9·5691	+34 27 12·7	0·6076	+0·15	+15·5	24
21	10 17 9	−3 42·18	+ 9 10·4	6–6	17 56 20·89	9·6426	+34 40 29·5	0·7845	+0·16	+15·8	25
24	7 20 33	+3 19·73	+ 0 28·9	7–7	18 2 2·42	9·5567	+34 58 26·7	0·5868	+0·08	+15·4	26
Nov. 12	7 29 12	+1 47·20	+ 6 35·6	3–3	18 40 45·42	9·6173	+36 57 44·8	0·6216	−0·08	+15·3	27
13	7 33 43	−0 54·52	− 3 14·6	6–6	18 42 53·00	9·6231	+37 4 14·3	0·6290	−0·08	+15·5	28

Remarks.

September 6.—Comet faint in bright moonlight; interrupted by clouds.

September 8.—Observation not quite satisfactory. Comet too faint in the moonlight.

September 30; October 12.—The R.A. comparisons of this comet are generally difficult to make owing to the elongated form of the nucleus in the direction of the parallel of declination. The individual results, therefore, do not run quite smoothly. The declinations are better.

October 3.—Comet faint in moonlight.

October 18.—Comet faint, sky hazy.

November 13.—Comet faint, observation very doubtful.

Comet faint, invisible after moonrise.

Date.	Greenwich Mean Time.	Comet—Star. $\Delta\alpha$.	$\Delta\delta$.	No. of Comps.	Comet's App. R.A.	Log. ($p \times \Delta$).	Comet's App. Dec.	Log. ($p \times \Delta$).	Red. to App. Place.	Comp. Star.
1889.	h m s	m s	′ ″		h m s		° ′ ″			
Aug. 29	11 3 12	+1 27·91	+ 3 3·2	6–6	0 6 8·07	−9·3341	− 5 54 43·6	0·8670	+2·19 +15·1	29
Sept. 1	10 50 3	−2 33·71	+ 0 9·2	7–7	0 5 0·40	−9·3348	− 5 51 7·0	0·8666	+2·22 +15·3	30
16	9 2 46	+1 30·55	− 0 12·1	8–7	23 56 51·81	−9·4220	− 5 32 34·0	0·8618	+2·40 +15·8	31
17	9 43 27	+0 50·98	+ 1 15·3	8–8	23 56 12·25	−9·3209	− 5 31 6·6	0·8658	+2·41 +15·8	31
18	9 6 32	+0 13·05	+ 2 52·6	8–8	23 55 34·32	−9·3972	− 5 29 29·3	0·8629	+2·42 +15·8	31
20	11 59 48	−1 10·11	+ 6 18·4	8–8	23 54 11·18	8·2361	− 5 26 3·4	0·8709	+2·43 +15·8	31
22	10 12 57	−2 25·42	+ 9 40·6	7–7	23 52 55·88	−9·1327	− 5 22 41·2	0·8686	+2·44 +15·8	31
23	10 39 28	+2 47·53	− 4 9·1	2–2	23 52 16·31	−8·9466	− 5 21 2·7	0·8696	+2·45 +15·8	32
25	8 47 51	+1 33·15	− 0 0·1	8–8	23 51 1·94	−9·3680	− 5 16 53·8	0·8633	+2·45 +15·8	32
30	9 37 38	+2 22·06	− 2 46·2	8–8	23 47 57·12	−9·1271	− 5 5 2·6	0·8672	+2·46 +15·8	33
Oct. 1	11 17 15	+1 44·99	+ 0 22·3	8–8	23 47 20·06	8·4661	− 5 1 54·1	0·8688	+2·47 +15·8	33
3	12 15 41	−0 49·49	− 1 36·5	8–8	23 46 12·75	9·1262	− 4 56 2·0	0·8665	+2·47 +15·7	34
14	7 49 59	−1 24·71	+ 0 19·2	8–8	23 41 41·83	−9·3000	− 4 14 48·0	0·8611	+2·44 +15·5	35
17	10 18 43	+3 0·63	− 4 41·5	5–5	23 40 56·68	8·6644	− 4 0 4·9	0·8635	+2·42 +15·4	36
19	8 55 57	+1 43·68	− 3 4·2	9–9	23 40 36·77	−8·8579	− 3 50 15·5	0·8625	+2·41 +15·4	37
21	11 8 40	+1 29·10	+ 8 24·6	8–8	23 40 22·18	9·1694	− 3 38 46·8	0·8602	+2·40 +15·3	37
24	10 19 53	−2 1·08	+ 0 36·5	8–8	23 40 15·49	8·9644	− 3 21 51·3	0·8599	+2·39 +15·3	38
27	10 10 19	+1 38·47	+ 0 40·7	9–9	23 40 25·46	8·9791	− 3 3 19·5	0·8582	+2·36 +15·2	39
30	10 1 36	+1 8·24	+ 1 31·0	4–4	23 40 51·55	8·9970	− 2 43 56·6	0·8564	+2·34 +15·1	40

Remarks.

September 25.—Comet not quite so well seen as previously; the reason of this is not apparent. Sky clear.
October 19.—Two small stars near the comet made the bisections difficult and uncertain. October 30.—Windy, clock difficult to hear.

Comet V. 1889 (*continued*).

Date.	Greenwich Mean Time.	Comet—Star. $\Delta\alpha$.	$\Delta\delta$.	No. of Comps.	Comet's App. R.A.	Log $(p\times\Delta)$.	Comet's App. Dec.	Log $(p\times\Delta)$.	Red. to App. Place.	Comp Star.
1889.	h m s	m s	′ ″		h m s		° ′ ″		s ″	
Oct. 31	12 33 22	+1 20·88	− 3 13·2	8–8	23 41 5·59	9·4737	− 2 36 36·8	0·8500	+2·34 +15·1	41
Nov. 12	6 21 42	+1 24·93	−12 37·0	8–8	23 45 49·88	−9·2288	− 1 7 39·8	0·8474	+2·26 +15·0	42
13	6 40 57	+2 0·56	− 4 14·3	8–8	23 46 25·50	−9·1361	− 0 59 17·2	0·8468	+2·25 +14·9	42
15	6 27 43	−1 27·69	−12 6·1	8–8	23 47 40·32	−9·1655	− 0 42 20·3	0·8453	+2·25 +14·9	43
25	6 42 33	+1 0·38	+ 4 55·0	8–8	23 55 27·79	−8·8823	+ 0 47 59·7	0·8367	+2·18 +14·7	44
26	6 45 56	−2 44·53	+ 2 8·4	8–8	23 56 23·05	−8·8209	+ 0 57 34·2	0·8357	+2·20 +14·7	45
Dec. 11	6 25 53	+2 3·94	− 0 4·3	7–7	0 12 29·18	−8·4787	+ 3 28 21·6	0·8196	+2·11 +14·5	46
12	6 54 27	+3 26·21	+ 0 47·5	8–8	0 13 43·70	8·2901	+ 3 39 7·4	0·8183	+2·10 +14·5	47
19	6 56 40	+1 9·16	− 7 44·7	8–8	0 22 43·64	8·7205	+ 4 54 3·6	0·8100	+2·10 +14·4	48
20	6 44 1	+2 28·96	+ 3 8·3	8–8	0 24 3·43	8·5635	+ 5 4 56·5	0·8085	+2·09 +14·3	48
24	8 20 44	−0 34·80	+ 4 10·3	9–9	0 29 38·44	9·2941	+ 5 49 27·4	0·8089	+2·10 +14·2	49
25	9 49 10	+3 13·89	− 1 2·3	8–8	0 31 7·52	9·4784	+ 6 1 19·2	0·8182	+2·07 +14·3	50
1890.										
Jan. 12	6 32 54	+2 0·83	− 8 10·6	9–9	0 58 12·03	9·0354	+ 9 21 37·2	0·7782	−1·07 − 5·6	51
20	7 16 16	+0 59·69	− 0 48·8	9–9	1 11 20·40	9·3009	+10 52 17·5	0·7746	−1·09 − 5·6	52
22	7 50 48	−0 43·56	− 6 7·1	8–8	1 14 43·55	9·3979	+11 14 50·1	0·7798	−1·09 − 5·5	53
Feb. 10	8 2 43	−1 27·46	− 4 32·7	7–8	1 47 48·14	9·4930	+14 43 38·1	0·7733	−1·18 − 5·2	54
11	7 58 59	+0 20·05	+ 6 9·2	8–8	1 49 35·64	9·4913	+14 54 19·9	0·7718	−1·19 − 5·3	54
12	7 16 39	−2 19·76	+ 2 23·2	4–4	1 51 17·1 ±	9·4284	+15 5 19 ±	0·7562	−1·18 − 5·2	55

Remarks.

November 13.—Bisections difficult owing to the neighbourhood of a small star. The companion comet was glimpsed, but the sky was not sufficiently transparent to admit of its observation. November 15.—Failed to see companion comet. Some fog.

November 25.—Again failed to see companion comet with certainty, though perhaps it was glimpsed at times. Windy.

December 19, 25.—Comet faint, sky hazy.

January 12, 20, 22; February 10.—Comet faint and difficult to observe accurately in R.A. The declinations are better.

Comet II. 1889 . . . (*Barnard's, March* 31, 1889.)

Date.	Greenwich Mean Time.	Comet—Star. Δα.	Δδ.	No. of Comps.	Comet's App. R.A.	Log ($p \times \Delta$).	Comet's App. Dec.	Log ($p \times \Delta$).	Red. to App. Place.		Comp. Star.
1889.	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Sept. 5	14 58 59	−2 5·95	+ 8 19·6	4–4	4 29 6·43	−9·3296	+ 2 44 12·0	0·8277	+1·21	+ 8·9	56
20	12 45 1	−0 58·52	− 4 2·6	8–7	3 55 42·67	−9·4207	− 2 0 20·0	0·8495	+1·77	+12·1	57
25	11 52 46	+2 16·78	+ 0 35·8	8–8	3 41 16·20	−9·4519	− 3 50 4·0	0·8548	+1·96	+13·2	58
30	11 59 20	+2 23·34	+ 1 42·1	8–9	3 25 4·52	−9·3737	− 5 45 17·8	0·8648	+2·13	+14·0	59
Oct. 21	11 54 15	−1 9·30	+ 8 8·0	1–1	2 5 19·73	−7·7808	−13 17 31·6	0·9037	+2·60	+14·3	60
24	11 57 44	−1 0·02	− 1 38·2	8–8	1 53 44·11	8·5777	−14 6 26·5	0·9062	+2·62	+13·9	61
27	11 13 19	−1 42·91	− 2 21·5	8–8	1 42 35·36	7·4374	−14 49 0·7	0·9089	+2·63	+13·5	62
31	11 40 33	−1 14·70	− 7 34·1	8–8	1 28 8·22	8·9846	−15 37 54·7	0·9089	+2·63	+12·9	63

Remarks.

September 5.—Comet faint and difficult to observe, a small star being near and on the same parallel.
October 21.—Cloudy after this comparison. October 27.—Comet very faint from fog.
October 31.—Comet faint, last two comparisons doubtful.

Comet VI. 1889 . . . (*Swift's, Nov.* 16, 1889.)

Dec. 11	7 5 14	+0 49·63	+ 2 36·2	6–6	23 44 14·81	8·9082	+18 47 26·1	0·6861	+1·96	+19·8	64
12	7 54 59	−2 36·93	+ 5 8·9	8–8	23 47 23·9±	9·2084	+19 5 56±	0·6938	+1·99	+19·9	65
24	9 24 22	−0 46·44	− 4 51·6	9–9	0 26 33·7±	9·4746	+22 22 34±	0·7045	+2·14	+20·0	66

Remarks.

December 11, 12, 24.—Comet very faint, a diffused mass without central condensation. I failed to see this comet on December 20 and 25; a very fine sky is required to see it satisfactorily.

Comet 1890 . . . (*Borrelly's, December* 12, 1889.)

Date.	Greenwich Mean Time.	Comet—Star. Δα.	Δδ.	No. of Comps.	Comet's App. R.A.	Log ($p \times \Delta$).	Comet's App. Dec.	Log ($p \times \Delta$).	Red. to App. Place.	Comp. Star.
1889.	h m s	m s	′ ″		h m s		° ′ ″		s	
Dec. 25	6 46 11	−1 10·15	+ 6 31″7	9–9	18 21 48·33	9·6369	+34 43 44″6	0·8022	−0·26	− 0″3	67

Remarks.

December 25.—Comet fairly bright, with condensation towards the centre, but without true nucleus.

Comet 1890 . . . (*Brooks's, March* 20, 1890.)

1890.										
April 16	14 33 12	−1 25·77	+ 7 27·7	8–8	21 9 22·08	−9·5660	+19 22 37·6	0·7787	−0·64	−14·5	68
22	14 8 25	−1 38·82	+ 0 17·1	8–8	21 6 44·46	−9·5768	+23 19 4·1	0·7573	−0·46	−15·2	69
29	13 34 15	+0 39·71	+ 9 15·0	6–6	21 1 33·35	−9·5967	+28 27 57·5	0·7264	−0·20	−15·9	70
29	13 59 53	+3 18·09	− 3 59·1	4–4	21 1 32·82	−9·5784	+28 28 51·3	0·7035	−0·18	−15·9	71
30	13 48 33	+3 30·97	+ 4 12·0	8–7	21 0 34·27	−9·5868	+29 15 49·3	0·7032	−0·14	−16·0	72
May 1	12 17 21	+1 58·98	− 4 14·5	8–8	20 59 36·19	−9·6234	+30 0 45·6	0·7772	−0·12	−16·1	73
11	11 27 11	+0 49·79	−11 11·9	4–4	20 44 41·01	−9·6684	+38 41 27·5	0·7266	+0·34	−16·7	74
13	10 51 12	+1 21·50	+ 9 22·7	8–8	20 40 27·47	−9·6789	+40 32 38·8	0·7443	+0·45	−16·6	75
14	11 52 49	−1 50·38	+ 5 47·4	8–8	20 38 1·5 ±	−9·6762	+41 32 6 ±	0·6442	+0·48	−16·7	76
15	11 53 58	+1 25·06	+ 2 51·4	7–7	20 35 30·25	−9·6793	+42 29 38·5	0·6229	+0·57	−16·6	77
20	12 33 46	+1 29·87	− 1 59·6	6–6	20 20 21·7 ±	−9·6530	+47 22 46 ±	0·3984	+0·92	−16·1	78
21	10 23 18	−2 22·92	+ 8 38·7	6–6	20 17 4·22	−9·7376	+48 17 53·5	0·6490	+0·96	−16·0	79
21	10 25 56	-1 18·19	+ 1 15·1	5–3	20 17 3·99	−9·7374	+48 17 57·1	0·6443	+0·97	−16·0	80
22	10 23 19	−2 9·76	+ 7 46·3	7–7	20 11 56·7 ±	−9·7459	+49 21 57 ±	0·6224	+1·06	−15·8	81
24	10 17 26	+3 3·23	− 2 8·1	6–6	20 4 3·69	−9·7602	+51 9 11·7	0·5837	+1·27	−15·2	82

Remarks.

May 20.—Observation not quite satisfactory; the star used is double, and the components are almost too wide to admit of its use as one mass.

Comparisons of the Companion of Brooks's Comet with the Main Body.

		h	Δα m	s	Δδ ′	″	Remarks.
Sept.	16	10	+0	20·82	+2	52·5	
	17	10	+0	20·95	+2	55·3	
	18	10	+0	20·59	+2	59·7	Observation not quite satisfactory.
	20	12	+0	20·90	+3	0·7	
	22	10	+0	20 68	+3	2·8	
	25	9	+0	20·89	+3	3·0	Companion not so well seen.
	30	10	+0	20·66	+3	1·2	
Oct.	1	12	+0	20·76	+3	4·1	Small star near, observation difficult.
	17	11	+0	20·75	+2	47·7	Doubtful, excessively faint.
	19	9	+0	18·91	+2	44·3	
	21	12	+0	18·28	+2	46·9	Doubtful, small star near.
	24	11	+0	18·24	+2	41·9	Companion excessively faint.
Nov.	12	7	+0	14·37	+2	21·0	

Assumed Mean Places of Comparison Stars.

Comet I. 1889.

Comp. Star.	R.A. 1889·0. h	m	s	Decl. 1889·0. °	′	″	Authority.
1	23	41	41·93	− 4	31	13·7	Equat. comparison with Glasg. 6237.
2	22	52	3·52	+ 2	38	8·7	Equat. comparisons with B.W.$_1$ 1114 and Schj. 9429.
3	22	14	27·79	+ 2	13	35·8	⅓ (B.W.$_1$ 247 + Lal. 43571–2 + Lam. 8777).
4	22	1	0·38	+ 1	53	58·6	⅓ (B.B. vi. + 1°·4584 + Lam. 8689 + Schj. 9020).
5	21	51	50·38	+ 1	44	49·1	½ (B.B. vi. + 1°·4563 + Lam. 8621).
6	21	44	24·83	+ 1	15	16·7	¼ (2 Glasg. 5592 + B.W.$_1$ 1014 + Lam. 8560).
7	20	25	12·25	− 1	50	59·7	½ (B.W.$_1$ 584 + Lam. 7600).

Comet V. 1888.

	9	19	29·17	+36	10	58·4	B.W.$_2$ 359.

Comet IV. 1889.

9	16	11	17·68	+24	33	11·5	Equat. comparison with B.B. vi. + 24°·2983. The place of this star is doubtful. (See catalogue.)
10	16	15	34·23	+24	52	10·4	Equat. comparisons with B.B. vi. + 24°·3000 and B.W.$_2$ 480.
11	16	17	24·35	+25	46	56·1	Equat. comparison with B.B. vi. + 25°·3063.

Comp. Star.	R.A. 1889·0.	Decl. 1889·0.	Authority.
	h m s	° ′ ″	
12	16 31 58·26	+27 23 28·8	Equat. comparison with B.W.$_2$ 991.
13	16 31 16·96	+28 5 55·7	B.W.$_2$ 916. The place of Lal. 30244, which is the same star, does not agree with this, the R.A. being 1^s·23 and the decl. 8″·2 greater. The wires in the Hist. Cel. are not accordant. (See note to Baily's Lalande.) They have probably been unadvisedly altered by Baily.
14	16 46 19·05	+29 59 47·1	50 Herculis. $\frac{1}{2}$ (Gr. 9 yr. 1531 + Yarn. 6980 + Arm.$_1$ 3473).
15	16 49 54·63	+30 1 4·3	Equat. comparison with * 14.
16	16 54 30·13	+30 17 12·1	B.W.$_2$ 1643.
17	17 2 39·06	+31 10 17·0	$\frac{1}{2}$ (B.W.$_2$ 3 + Lal. 31201).
18	17 3 46·96	+31 21 5·0	B.W.$_2$ 46.
19	17 17 55·39	+32 5 34·3	$\frac{1}{2}$ (B.W.$_2$ 482 + Rümk. 5810).
20	17 22 31·91	+32 36 32·9	B.W.$_2$ 628.
21	17 42 6·19	+33 47 4·6	Equat. comparisons with B.W.$_2$ 1356 and Lal. 32616.
22	17 39 21·40	+33 59 45·2	B.B. vi. + 34°·3031.
23	17 48 15·87	+34 13 52·3	Lal. 32772.
24	17 50 41·83	+34 27 3·9	Equat. comparison with B.W.$_2$ 1658.
25	18 0 2·91	+34 31 3·3	Equat. comparisons with B.W.$_2$ 10 and B.B. vi. + 34°·3122.
26	17 58 42·61	+34 57 42·4	$\frac{1}{2}$ (B.W.$_2$ 1839 + B.B. vi. + 34°·3106).
27	18 38 58·30	+36 50 54·0	B.W.$_2$ 1146.
28	18 43 47·60	+37 7 13·5	B.W.$_2$ 1306.
		Comet V. 1889.	
29	0 4 37·97	− 5 51 55·5	$\frac{1}{3}$ (Glasg. 22 + Yarn. 35 + Gr. 9 yr. 6).
30	0 7 31·89	− 5 51 31·5	$\frac{1}{2}$ (B.W.$_1$ 93 + Schj. 48).
31	23 55 18·85	− 5 32 37·7	Yarn. 10604. B.W.$_1$ 1099 is the same star but its R.A. is 0^s·95 greater than that here given.
32	23 49 26·34	− 5 17 9·5	B.W.$_1$ 973. Lal. 46872 is the same star but its decl. is 12″·4 less than that given by Weisse.
33	23 45 32·60	− 5 2 32·2	Equat. comparisons with Yarn. 10499 and B.W.$_1$ 915.
34	23 46 59·77	− 4 54 41·3	B.W.$_1$ 915.
35	23 43 4·10	− 4 15 22·6	$\frac{1}{2}$ (Schj. 9844 + Lam. 4773).
36	23 37 53·64	− 3 55 38·8	$\frac{1}{2}$ (B.W.$_1$ 736 + Schj. 9800).
37	23 38 50·68	− 3 47 26·7	$\frac{1}{3}$ (Arm.$_2$ 3232 + Glasg. 6281 + B.W.$_1$ 755).
38	23 42 14·17	− 3 22 43·1	*Newcomb Standard Cat.* 1083 = 20 *Piscium*.

Comp. Star.	R.A. 1889·0.	Decl. 1889·0.	Authority.
	h m s	° ′ ″	
39	23 38 44·63	− 3 4 15·4	Equat. comparison with Dunsink Cat. 991.
40	23 39 40·97	− 2 45 42·8	Equat. comparison with B.W.$_1$ 812.
41	23 39 42·37	− 2 33 38·7	Equat. comparison with B.W.$_1$ 812.
42	23 44 22·69	− 0 55 17·8	Equat. comparison with B.W.$_1$ 733.
43	23 49 5·76	− 0 30 29·0	⅓ (Glasg. 6346 + Yarn. 10544 + Gr. 9 yr. 2241).
44	23 54 25·23	+ 0 42 50·1	Equat. comparison with B.W.$_1$ 1002.
45	23 59 5·38	+ 0 55 11·1	⅓ (Yarn. 10934 + Glasg. 6404 + B.W.$_1$ 1179).
46	0 10 23·13	+ 3 28 11·5	Equat. comparisons with Glasg. 52 and B.B. vi. + 3°·28.
47	0 10 15·39	+ 3 38 5·5	½ (Glasg. 52 + Yarn. 99).
48	0 21 32·38	+ 5 1 33·8	Equat. comparisons with B.W.$_1$ 282 and 285. It is possible that the R.A. of this star is 1 second too great.
49	0 30 11·14	+ 5 45 2·9	Rümk. 234.
50	0 27 51·56	+ 6 2 7·2	Schj. 184.
	1890·0.	1890·0.	
51	0 56 12·27	+ 9 29 53·4	½ (B.W.$_1$ 950 + Yarn. 535).
52	1 10 21·80	+10 53 11·9	B.W.$_1$ 119.
53	1 15 28·20	+11 21 2·7	½ (B.W.$_1$ 208 + Yarn. 680).
54	1 49 16·78	+14 48 16·0	Lal. 3527.
55	1 53 38·1 ±	+15 3 1 ±	A.Z. + 14°·321.

Comet II. 1889.

56	4 31 11·17	+ 2 35 43·5	Equat. comparison with B.W.$_1$ 633.
57	3 56 39·42	− 1 56 29·5	⅓ (B.W.$_1$ 1068 + Schj. 1259 + Paris 4684).
58	3 38 57·46	− 3 50 52·9	½ (B.W.$_1$ 709 + Schj. 1135).
59	3 22 39·05	− 5 47 13·8	Equat. comparison with Paris 4059. The star Paris 4059 is also to be found in Weisse's Bessel, Schjellerup, and Lalande, but no two of these authorities agree. Possibly Schjellerup's R.A. is 1 second too small, and the star may have a large proper motion in declination (about −0″·9). The place given in the *Paris Cat.* is used unaltered.
60	2 6 26·43	−13 25 53·9	½ (B.W.$_1$ 59 + Santini 150).
61	1 54 41·51	−14 5 2·2	⅓ (B.W.$_1$ 945 + Santini 138 + Paris 2502).
62	1 44 15·63	−14 46 52·7	½ (B.W.$_1$ 759 + Santini 119).
63	1 29 20·29	−15 30 33·5	Equat. comparison with Arg. (Oelt.) 987.

Comet VI. 1889.

Comp. Star.	R.A. 1889·0.	Decl. 1889·0.	Authority.
	h m s	° ′ ″	
64	23 43 23·23	+18 44 30·0	Lamont 1811.
65	23 49 58·8 ±	+19 0 27 ±	A.Z. + 18°·5240.
66	0 27 18·0 ±	+22 27 5 ±	A.Z. + 22°·81.

Comet 1890.

67	18 22 58·73	+34 37 13·2	Lal. 34191.

Comet 1890.

Comp. Star.	R.A. 1890·0.	Decl. 1890·90.	Authority.
	h m s	° ′ ″	
68	21 10 48·49	+19 15 24·4	⅓ (Arm.$_2$ 2796 + Rümk. 9068 + Lal. 41312)
69	21 8 23·74	+23 19 2·2	B.W.$_2$ 143.
70	21 0 53·84	+28 18 58·4	½ (Lal. 40906 + Rümk. 8875).
71	20 58 14·91	+28 33 6·4	½ (Rümk. 8837 + B.W.$_2$ 1765).
72	20 57 3·44	+29 11 57·6	Lal. 40763.
73	20 57 37·33	+30 5 16·2	½ (Rümk. 8823 + B.W.$_2$ 1748).
74	20 43 50·89	+38 52 56·2	½ (Yarn. 9323 + Arm.$_2$ 2710).
75	20 39 5·53	+40 23 32·7	B.W.$_2$ 1280.
76	20 39 51·4 ±	+41 26 35 ±	A.Z. + 41°·3868.
77	20 34 4·62	+42 27 3·7	½ (Rad., 4896 + Lal. 39928–30). The observations of Lalande appear to be confirmed by Groombridge, but do not agree well with the *Radcliffe Cat.*, the difference in declination being as much as 13″·3. The mean of these authorities is used with much diffidence.
78	20 18 50·9 ±	+47 25 3 ±	A.Z. + 47°·3089.
79	20 19 26·18	+48 9 30·7	Arg. (Oelt.) 20451.
80	20 18 21·20	+48 16 58·0	Arg. (Oelt.) 20427.
81	20 14 5·4 ±	+49 14 26 ±	A.Z. + 49°·3246.
82	20 0 59·19	+51 11 34·9	B.B. vi. + 51°·2754.

Ipswich: November 10, 1890.

Ephemerides of the Satellites of Saturn, 1890–91. By A. Marth.

(*Continued from p.* 557 *of preceding volume.*)

Differences of right ascension and declination between Titan and Iapetus and the centre of Saturn.

Greenwich Noon.	*Titan.*		*Iapetus.*	
	$\alpha_s - A$	$\delta_s - D$	$\alpha_s - A$	$\delta_s - D$
1890.	s	"	s	"
Dec. 26	−11·35	−17·4	+36·05	−47·6
27	− 8·32	−15·9	36·48	52·7
28	− 4·09	−12·1	36·69	57·4
29	+ 0·76	− 6·5	36·67	61·8
30	+ 5·50	+ 0·1	36·42	65·8
31	+ 9·40	+ 6·6	35·94	69·4
1891.				
Jan. 1	+11·80	+12·2	+35·24	−72·6
2	+12·26	+15·8	34·30	75·3
3	+10·67	+16·7	33·14	77·5
4	+ 7·29	+14·9	31·76	79·1
5	+ 2·70	+10·7	30·16	80·3
6	− 2·34	+ 4·7	28·36	80·9
7	− 7·05	− 2·0	+26·37	−81·0
8	−10·71	− 8·5	24·19	80·5
9	−12·81	−13·8	21·84	79·5
10	−13·09	−17·2	19·34	77·9
11	−11·51	−18·2	16·70	75·8
12	− 8·30	−16·6	+13·93	−73·1
13	− 3·88	−12·7	11·05	70·0
14	+ 1·11	− 6·9	8·09	66·3
15	+ 5·95	− 0·1	5·07	62·2
16	+ 9·87	+ 6·9	+ 2·00	57·6
17	+12·20	+12·7	− 1·10	−52·6
18	+12·53	+16·5	4·20	47·2
19	+10·75	+17·7	7·28	41·5
20	+ 7·17	+15·9	10·31	35·5
21	+ 2·41	+11·5	13·29	29·2
22	− 2·79	+ 5·3	−16·18	−22·8
23	− 7·55	− 1·8	18·97	16·2
24	−11·19	− 8·7	21·63	9·5

Greenwich Noon. 1891.	*Titan.* $\alpha_s - A$	$\delta_s - D$	*Iapetus.* $\alpha_s - A$	$\delta_s - D$
	s	"	s	"
Jan. 25	−13·21	−14·4	−24·16	− 2·7
26	−13·34	−18·1	26·52	+ 4·1
27	−11·57	−19·3	−28·71	10·8
28	− 8·15	−17·9	30·71	17·5
29	− 3·56	−13·9	32·50	24·0
30	+ 1·57	− 7·8	34·07	30·3
31	+ 6·47	− 0·6	35·42	36·4
Feb. 1	+10·36	+ 6·8	−36·53	+42·2
2	+12·57	+13·2	37·40	47·8
3	+12·71	+17·5	38·03	52·9
4	+10·72	+18·9	38·40	57·7
5	+ 6·92	+17·3	38·52	62·1
6	+ 1·96	+12·8	−38·39	+66·1
7	− 3·31	+ 6·3	38·01	69·6
8	− 8·09	− 1·3	37·38	72·6
9	−11·66	− 8·8	36·51	75·2
10	−13·54	−15·0	35·40	77·2
11	−13·47	−19·2	−34·07	+78·7
12	−11·45	−20·8	32·52	79·7
13	− 7·87	−19·5	30·76	80·1
14	− 3·12	−15·4	28·81	80·1
15	+ 2·13	− 9·1	26·67	79·5
16	+ 7·01	− 1·3	−24·37	+78·4
17	+10·81	+ 6·8	21·91	76·9
18	+12·86	+13·8	19·32	74·9
19	+12·77	+18·7	16·60	72·4
20	+10·54	+20·5	13·78	69·4
21	+ 6·54	+18·9	−10·87	+66·1
22	+ 1·46	+14·3	7·89	62·3
23	− 3·87	+ 7·4	4·86	58·2
24	− 8·61	− 0·7	− 1·80	53·8
25	−12·06	− 8·8	+ 1·29	49·0
26	−13·75	−15·7	4·34	+44·0
27	−13·46	−20·5	7·38	38·8
28	−11·28	−22·5	10·39	33·3
Mar. 1	− 7·47	−21·3	13·33	27·7
2	− 2·59	−17·1	16·19	22·0
3	+ 2·67	−10·4	+18·96	+16·2

Greenwich Noon. 1891.	*Titan.* $\alpha_s - A$	*Titan.* $\delta_s - D$	*Iapetus.* $\alpha_s - A$	*Iapetus.* $\delta_s - D$
	s	″	s	″
Mar. 4	+ 7·52	− 2·0	+21·61	+10·3
5	+11·18	+ 6·7	24·14	+ 4·3
6	+13·02	+14·4	26·52	− 1·6
7	+12·69	+19·9	28·74	7·4
8	+10·24	+22·0	+30·78	−13·1
9	+ 6·07	+20·6	32·64	18·7
10	+ 0·89	+15·8	34·30	24·2
11	− 4·43	+ 8·5	35·74	29·4
12	− 9·06	− 0·2	36·96	34·4
13	−12·34	− 9·0	+37·95	−39·2
14	−13·81	−16·5	38·71	43·6
15	−13·31	−21·7	39·22	47·7
16	−10·91	−24·0	39·48	51·5
17	− 6·97	−22·9	39·49	55·0
18	− 2·02	−18·5	+39·26	−58·0
19	+ 3·21	−11·4	38·76	60·6
20	+ 7·95	− 2·6	38·02	62·8
21	+11·42	+ 6·8	37·03	64·6
22	+13·03	+15·1	35·79	65·9
23	+12·47	+21·0	+34·32	−66·7
24	+ 9·82	+23·4	32·63	67·1
25	+ 5·53	+22·0	30·72	67·0
26	+ 0·34	+17·0	28·61	66·5
27	− 4·91	+ 9·2	26·31	65·5
28	− 9·39	+ 0·1	+23·83	−64·1
29	−12·46	− 9·2	21·20	62·3
30	−13·72	−17·2	18·42	60·0
31	−13·01	−22·9	15·52	57·3
Apr. 1	−10·46	−25·2	12·52	54·2
2	− 6·43	−24·1	+ 9·43	−50·8
3	− 1·48	−19·5	6·29	47·1
4	+ 3·68	−12·1	+ 3·12	43·1
5	+ 8·26	− 2·8	+ 0·08	38·8
6	+11·52	+ 7·0	3·26	34·2
7	+12·90	+15·6	− 6·42	−29·5
8	+12·15	+21·7	9·52	24·6
9	+ 9·34	+24·2	12·55	19·5
10	+ 5·00	+22·7	15·48	14·4

Greenwich Noon. 1891.	*Titan.* $\alpha_s - A$	$\delta_s - D$	*Iapetus.* $\alpha_s - A$	$\delta_s - D$
	s	"	s	"
Apr. 11	− 0·16	+ 17·5	− 18·30	− 9·2
12	− 5·28	+ 9·5	− 20·98	− 4·0
13	− 9·58	0·0	23·51	+ 1·2
14	− 12·45	− 9·5	25·87	6·3
15	− 13·50	− 17·7	28·04	11·4
16	− 12·62	− 23·4	30·02	16·3
17	− 9·97	− 25·8	− 31·78	+ 21·1
18	− 5·90	− 24·5	33·32	25·7
19	− 1·00	− 19·8	34·64	30·1
20	+ 4·03	− 12·1	35·71	34·3
21	+ 8·43	− 2·6	36·54	38·2
22	+ 11·48	+ 7·3	− 37·13	+ 41·8
23	+ 12·66	+ 16·0	37·47	45·2
24	+ 11·73	+ 22·1	37·56	48·2
25	+ 8·85	+ 24·5	37·41	50·8
26	+ 4·50	+ 22·8	37·02	53·1
27	− 0·57	+ 17·5	− 36·39	+ 55·1
28	− 5·53	+ 9·3	35·53	56·7
29	− 9·64	− 0·3	34·45	58·0
30	− 12·30	− 9·8	33·16	58·9
May 1	− 13·18	− 17·9	31·66	59·4
2	− 12·17	− 23·4	− 29·98	+ 59·6
3	− 9·47	− 25·7	28·12	59·4
4	− 5·43	− 24·3	26·10	58·8
5	− 0·62	− 19·4	23·92	57·9
6	+ 4·26	− 11·7	21·61	56·7
7	+ 8·47	− 2·2	− 19·18	+ 55·1
8	+ 11·33	+ 7·6	16·64	53·2
9	+ 12·34	+ 16·1	14·01	51·1
10	+ 11·30	+ 22·0	11·32	48·6
11	+ 8·38	+ 24·1	8·56	45·9
12	+ 4·09	+ 22·2	− 5·77	+ 42·9
13	− 0·86	+ 16·7	2·95	39·7
14	− 5·66	+ 8·6	− 0·13	36·3
15	− 9·58	− 0·8	+ 2·68	32·7
16	− 12·07	− 10·1	5·46	28·9
17	− 12·82	− 17·8	+ 8·21	+ 25·0
18	− 11·75	− 23·0	10·89	21·0

Greenwich Noon. 1891.	*Titan.* $\alpha_s - A$	$\delta_s - D$	*Iapetus.* $\alpha_s - A$	$\delta_s - D$
	s	″	s	″
May 19	− 9·03	−25·0	+13·50	+16·8
20	− 5·04	−23·3	16·03	12·5
21	− 0·34	−18·3	18·45	8·2
22	+ 4·38	−10·7	+20·76	+ 3·9
23	+ 8·38	− 1·5	22·94	− 0·5
24	+11·11	+ 8·0	24·97	4·8
25	+11·99	+16·0	26·86	9·1
26	+10·89	+21·4	28·58	13·3
27	+ 7·98	+23·1	+30·13	−17·5
28	+ 3·76	+21·0	31·50	21·6
29	− 1·05	+15·5	32·68	25·6
30	− 5·68	+ 7·6	33·66	29·4
31	− 9·44	− 1·5	34·44	33·0
June 1	−11·79	−10·2	+35·01	−36·4
2	−12·45	−17·5	35·38	39·7
3	−11·34	−22·2	35·53	42·7
4	− 8·65	−23·7	35·46	45·5
5	− 4·74	−21·8	35·18	48·0
6	− 0·17	−16·8	+34·69	−50·2
7	+ 4·40	− 9·4	33·98	52·1
8	+ 8·28	− 0·6	33·07	53·7
9	+10·84	+ 8·3	31·96	55·0
10	+11·64	+15·7	30·66	56·0
11	+10·51	+20·4	+29·16	−56·7
12	+ 7·65	+21·7	27·49	57·0
13	+ 3·53	+19·3	25·65	56·9
14	− 1·15	+13·9	23·65	56·5
15	− 5·63	+ 6·2	21·51	55·7
16	− 9·25	− 2·3	+19·24	−54·6
17	−11·49	−10·4	16·85	53·2
18	−12·09	−16·9	14·36	51·4
19	−10·99	−21·0	11·79	49·3
20	− 8·34	−22·0	9·15	46·9
21	− 4·54	−19·9	+ 6·45	−44·1
22	− 0·09	−14·9	3·73	41·1
23	+ 4·34	− 7·8	+ 0·99	37·8
24	+ 8·10	+ 0·5	− 1·75	34·3
25	+10·57	+ 8·5	4·46	30·5

Greenwich Noon. 1891.	*Titan.* $\alpha_s - A$	$\delta_s - D$	*Iapetus.* $\alpha_s - A$	$\delta_s - D$
	s	″	s	″
June 26	+11·32	+15·1	− 7·13	−26·5
27	+10·20	+19·1	9·75	22·3
28	+ 7·39	+19·9	12·30	17·9
29	+ 3·38	+17·3	14·75	13·4
30	− 1·17	+11·9	17·10	8·8
July 1	− 5·52	+ 4·7	−19·32	− 4·2
2	− 9·03	− 3·1	21·41	+ 0·5
3	−11·21	−10·4	23·35	5·3
4	−11·78	−16·2	25·14	10·0
5	−10·70	−19·5	26·75	14·7
6	− 8·12	−20·0	−28·19	+19·3
7	− 4·41	−17·7	29·44	23·9
8	− 0·08	−12·8	30·50	28·3
9	+ 4·23	− 6·0	31·37	32·5
10	+ 7·91	+ 1·6	32·03	36·6
11	+10·31	+ 8·8	−32·49	+40·5
12	+11·04	+14·5	32·74	44·2
13	+ 9·95	+17·7	32·79	47·6
14	+ 7·21	+17·9	32·64	50·8
15	+ 3·30	+15·0	32·29	53·7
16	− 1·13	+ 9·8	−31·75	+56·3

Approximate Greenwich times of conjunctions of the satellites with the ends of the ring (*f* conj. with the *f*ollowing, *p* with the *p*receding end), *n* north, *s* south of the major axis of the ring. The intervals of time between these conjunctions and the conjunctions with the end points of the equatorial diameter of the ball or the passages through the tangents to the limb at these end points are for Mi. about $1^h{\cdot}8$, En. $1^h{\cdot}9$, Te. $2^h{\cdot}0$, Di. $2^h{\cdot}2$, Rh. $2^h{\cdot}6$.

1890.	h		h		h
Dec. 27	9·8 Te. fn	Dec. 28	15·2 En. fn	Dec. 29	20·8 Mi. pn
	10·0 Di. w		15·5 Te. fs		22·0 Te. w
	12·2 Mi. fs		16·2 Mi. fn		23·1 Rh. ps
	12·7 En. pn		18·9 Di. e	30	0·1 En. fn
	16·8 Te. pn		20·4 Tit. sup. ♂		12·8 Te. fs
	16·9 Rh. fn		s. 7″ Occult.		13·5 Mi. fn
	17·6 Mi. fn		21·6 En. pn		16·2 Di. ps
	22·5 Di. ps		22·2 Mi. pn		16·6 En. ps
	22·8 En. ps.		23·3 Te. e		19·4 Mi. pn
	23·5 Mi pn	29	0·5 Rh. w		20·6 Te. e
28	0·7 Te. w		14·0 Te. pn		22·9 En. fs
	1·9 Rh. pn		14·0 En. fs	31	0·0 Di. fs
	8·6 Te. ps		14·9 Mi. fn		11·4 Te. pn
	10·8 Mi. fs		15·2 Di. pn		12·1 Mi. fn

1890. h
Dec. 31 12·5 Di. e
15·4 En. pn
18·0 Mi. pn
19·3 Te. w
23·4 Mi. ps

1891.
Jan. 1 1·1 Di. fn
1·4 En. ps
10·1 Te. fs
10·7 Mi. fn
14·3 Rh. pn
16·6 Mi. pn
17·9 En. fn
17·9 Te. e
21·4 Di. w
22·0 Mi. ps
2 0·2 En. pn
1·7 Te. fn
9·9 Di. ps
10·3 En. ps
12·9 Rh. w
15·2 Mi. pn
16·6 Te. w
16·7 En. fs
17·7 Di. fs
20·6 Mi. ps
3 0·4 Te. ps
11·5 Rh. ps
13·9 Mi. pn
15·2 Te. e
18·7 Di. fn
19·2 En. ps
19·2 Mi. ps
20·5 Rh. fs
23·0 Te. fn
4 11·6 En. fn
12·5 Mi. pn
13·9 Te. w
15·1 Di. w
17·9 Mi. ps
18·0 En. pn
19·1 Rh. e
21·7 Te. ps
23·8 Mi. fs
5 10·4 En. fs
11·1 Mi. pn
11·4 Di. fs
12·5 Te. e
13·1 Tit. inf. ♂ n 8″ Transit.
5 16·5 Mi. ps
17·7 Rh. fn
20·3 Te. fn
20·5 En. fn
22·4 Mi. fs
23·9 Di. e
6 11·2 Te. w
12·4 Di. fn
13·0 En. ps

Jan. 6 h
15·1 Mi. ps
19·0 Te. ps
19·3 En. fs
20·2 Di. pn
21·7 Mi. fs
7 1·3 Rh. w
8·7 Di. w
9·8 Te. e
11·8 En. pn
13·7 Mi. ps
17·6 Te. fn
19·6 Mi. fs
21·3 Di. ps
21·8 En. ps
23·9 Rh. ps
8 0·6 Te. pn
8·5 Te. w
8·9 Rh. fs
12·3 Mi. ps
14·3 En. fn
16·3 Te. ps
17·6 Di. e
18·2 Mi. fs
20·6 En. pn
23·3 Te. fs
23·6 Mi. fn
9 7·1 Te. e
7·5 Rh. e
10·9 Mi. ps
13·1 En. fs
13·9 Di. pn
15·0 Te. fn
16·8 Mi. fs
21·9 Te. pn
22·2 Mi. fn
23·2 En. fn
10 13·6 Te. ps
14·9 Di. ps
15·1 Rh. pn
15·5 Mi. fs
15·6 En. ps
20·6 Te. fs
20·9 Mi. fn
22·0 En. fs
22·7 Di. fs
11 11·2 Di. e
12·2 Te. fn
13·7 Rh. w
14·1 Mi. fs
14·4 En. pn
19·2 Te. pn
19·5 Mi. fn
23·8 Di. fn
12 0·5 En. ps
10·9 Te. ps
12·3 Rh. ps
12·7 Mi. fs
16·9 En. fn
17·9 Te. fs

Jan. 12 h
18·1 Mi. fn
20·1 Di. w
21·3 Rh. fs
23·3 En. pn
13 8·6 Di. ps
9·4 En. ps
9·5 Te. fn
11·3 Mi. fs
15·7 En. fs
16·4 Di. fs
16·5 Te. pn
16·7 Mi. fn
18·9 Tit. sup. ♂ s. 8″. Occult.
19·9 Rh. e
22·6 Mi. pn
14 0·4 Te. w
15·2 Te. fs
15·3 Mi. fn
17·4 Di. fn
18·2 En. ps
18·5 Rh. fn
21·2 Mi. pn
23·0 Te. e
15 10·7 En. fn
13·7 Di. w
13·8 Te. pn
13·9 Mi. fn
17·0 En. pn
19·8 Mi. pn
21·7 Te. w
16 9·5 En. fs
10·1 Di. fs
12·5 Te. fs
12·5 Mi. fn
18·5 Mi. pn
19·6 En. fn
20·3 Te. e
22·6 Di. e
23·9 Mi. ps
17 0·6 Rh. ps
9·6 Rh. ps
11·1 Di. fn
11·1 Te. pn
11·2 Mi. fn
12·0 En. ps
17·1 Mi. pn
18·4 En. fs
18·9 Di. pn
19·0 Te. w
18 8·2 Rh. e
9·8 Te. fs
9·8 Mi. fn
10·8 En. pn
15·7 Mi. pn
17·6 Te. e
19·9 Di. ps
20·9 En. ps
21·1 Mi. ps

1891.	h			h			h
Jan. 19	13·3	En. fn	Jan. 25	23·6	En. fs	Feb. 2	20·0 Te. e
	14·3	Mi. pn		23·9	Di. pn		21·1 Di. fn
	15·8	Rh. pn	26	10·4	Rh. fs	3	10·2 Mi. fn
	16·2	Di. e		12·4	Di. w		10·8 Te. pn
	16·3	Te. w		14·6	Te. fn		15·0 En. fn
	19·7	En. pn	27	8·7	Di. fs		16·1 Mi. pn
	19·7	Mi. ps		9·0	Rh. e		17·4 Di. w
20	12·1	En. fs		13·3	Te. ps		18·6 Te. w
	12·6	Di. pn	28	9·7	Di. fn		21·3 En. pn
	12·9	Mi. pn		11·0	En. ps		21·5 Mi. ps
	14·4	Rh. w		11·9	Te. fn	4	9·4 Te. fs
	14·9	Te. e		13·1	Mi. fs		11·1 Rh. fs
	18·3	Mi. ps		16·5	Rh. pn		13·7 Di. fs
	22·2	En. fn		17·4	En. fs		13·8 En. fs
	22·7	Te. fn		17·5	Di. pn		14·7 Mi. pn
21	11·4	Tit. inf. ♂		18·5	Mi. fn		17·3 Te. e
	n. 9″?	Transit		18·9	Te. pn		20·1 Mi. ps
	11·5	Mi. pn	29	9·8	En. pn	5	9·7 Rh. e
	13·0	Rh. ps		10·6	Te. ps		13·3 Mi. pn
	13·6	Te. w		11·7	Mi. fs		14·7 Di. fn
	13·6	Di. ps		15·1	Rh. w		15·9 Te. w
	14·6	En. ps		16·8	Tit. sup. ♂		16·3 En. ps
	16·9	Mi. ps			s. 10″		18·7 Mi. ps
	21·0	En. fs		17·1	Mi. fn		22·5 Di. pn
	21·4	Te. ps		17·6	Te. fs		22·6 En. fs
	21·4	Di. fs		18·6	Di. ps	6	9·2 Tit. inf. ♂
	22·0	Rh. fs		19·9	En. ps		n. 10″
22	9·9	Di. e	30	9·2	Te. fn		11·0 Di. w
	10·1	Mi. pn		10·3	Mi. fs		12·0 Mi. pn
	12·2	Te. e		12·3	En. fn		14·6 Te. e
	13·4	En. pn		13·7	Rh. ps		15·1 En. pn
	15·5	Mi. ps		14·9	Di. e		17·2 Rh. pn
	20·0	Te. fn		15·8	Mi. fn		17·4 Mi. ps
	20·6	Rh. e		16·2	Te. pn		22·4 Te. fn
	21·4	Mi. fs		18·7	En. pn	7	10·6 Mi. pn
	22·4	Di. fn		21·7	Mi. pn		13·2 Te. w
	23·5	En. ps		22·7	Rh. fs		15·8 Rh. w
23	10·9	Te. w	31	11·1	En. fs		16·0 Mi. ps
	14·2	Mi. ps		11·2	Di. pn		17·6 En. fn
	16·0	En. fn		14·4	Mi. fn		19·9 Di. e
	18·7	Te. ps		14·9	Ti. fs		21·0 Te. ps
	18·7	Di. w		20·3	Mi. pn	8	10·0 En. ps
	19·2	Rh. fn		21·2	En. fn		11·8 Te. e
	20·1	Mi. fs		21·3	Rh. e		14·4 Rh. ps
	22·3	En. pn		22·7	Te. e		14·6 Mi. ps
24	9·5	Te. e	Feb. 1	12·2	Di. ps		16·2 Di. pn
	12·8	Mi. ps		13·0	Mi. fn		16·4 En. fs
	14·8	En. fs		13·5	Te. pn		19·7 Te. fn
	15·1	Di. fs		13·7	En. ps		20·5 Mi. fs
	17·3	Te. fn		18·9	Mi. pn	9	8·8 En. pn
	18·7	Mi. fs		19·9	Rh. fn		10·5 Te. w
25	8·1	Te. w		20·0	Di. fs		13·2 Mi. ps
	11·4	Mi. ps		20·0	En. fs		17·2 Di. ps
	16·0	Te. ps		21·3	Te. w		18·3 Te. ps
	16·1	Di. fn	2	8·5	Di. e		18·9 En. ps
	17·3	En. ps		11·6	Mi. fn		19·1 Mi. fs
	17·3	Mi. fs		12·1	Te. fs	10	9·1 Te. e
	22·7	Mi. fn		12·5	En. pn		11·4 En. fn
	23·0	Te. fs		17·5	Mi. pn		11·8 Mi. ps

1891.	h					h					h
Feb.	10	13·5	Di. e	Feb.	16	21·1	Di. pn	Feb.	24	20·9	Mi. fs
		17·0	Te. fn			21·7	En. fs		25	11·5	Te. e
		17·7	En. pn		17	9·6	Di. w			13·0	En. fn
		17·7	Mi. fs			13·4	Mi. fn			13·6	Mi. ps
		20·6	Rh. fn			14·1	En. pn			14·6	Di. w
	11	7·8	Te. w			14·5	Te. fs			17·1	Rh. w
		9·8	Di. pn			15·1	Rh. ps			19·3	Te. fn
		10·2	En. fs			19·3	Mi. pn			19·4	En. pn
		10·4	Mi. ps			22·2	Di. ps			19·5	Mi. fs
		15·6	Te. ps			22·3	Te. e		26	10·1	Te. w
		16·3	Mi. fs		18	12·0	Mi. fn			10·9	Di. fs
		20·2	En. fn			13·1	Te. pn			11·8	En. fs
		21·7	Mi. fn			16·6	En. fn			12·2	Mi. ps
		22·3	Di. w			17·9	Mi. pn			15·7	Rh. ps
		22·6	Te. fs			18·5	Di. e			17·9	Te. ps
	12	10·8	Di. ps			20·9	Te. w			18·1	Mi. fs
		12·7	En. ps			22·7	Rh. e			21·9	En. fn
		14·2	Te. fn		19	9·1	En. ps		27	8·8	Te. e
		14·9	Mi. fs			10·6	Mi. fn			10·9	Mi. ps
		18·6	Di. fs			11·8	Te. fs			11·9	Di. fn
		19·0	En. fs			14·8	Di. pn			14·3	En. ps
		20·3	Mi. fn			15·4	En. fs			16·6	Te. fn
		21·2	Te. pn			16·5	Mi. pn			16·8	Mi. fs
	13	11·5	En. pn			19·6	Te. e			19·7	Di. pn.
		11·7	Rh. fs			21·2	Rh. fn			20·7	En. fs
		12·9	Te. ps		20	9·2	Mi. fn		28	7·4	Te. w
		13·6	Mi. fs			10·4	Te. pn			8·2	Di. w
		19·0	Mi. fn			15·2	Mi. pn			9·5	Mi. ps
		19·7	Di. fn			15·8	Di. ps			13·1	En. pn
		19·9	Te. fs			17·9	En. ps			15·2	Te. ps
		21·5	En. ps			18·2	Te. w			15·4	Mi. fs
	14	10·3	Rh. e			20·6	Mi. ps			20·8	Di. ps
		11·5	Te. fn		21	9·1	Te. fs			20·8	Mi. fn
		12·2	Mi. fs			10·4	En. fn			21·9	Rh. fn
		14·0	En. fn			12·1	Di. e			22·2	Te. fs
		14·6	Tit. sup. ♂			13·8	Mi. pn	Mar.	1	6·0	Te. e
			s. 12″			16·7	En. pn			6·9	Rh. pn
		16·0	Di. w			16·9	Te. e			8·1	Mi. ps
		17·6	Mi. fn			19·2	Mi. ps			13·9	Te. fn
		18·5	Te. pn		22	6·9	Tit. inf. ♂			14·0	Mi. fs
		20·4	En. pn				n. 12″			15·6	En. fn
	15	8·9	Rh. fn			7·7	Te. pn			17·1	Di. e
		10·2	Te. ps			8·4	Di. pn			19·4	Mi. fn
		10·8	Mi. fs			9·2	En. fs			20·9	Te. pn
		12·3	Di. fs			12·4	Rh. fs			22·0	En. pn
		12·8	En. fs			12·4	Mi. pn		2	8·1	En. ps
		16·2	Mi. fn			15·5	Te. w			12·2	Tit. sup. ♂
		16·7	Te. fs		23	9·5	Di. ps				s. 14″
		17·9	Rh. pn			11·0	Rh. e			12·5	Te. ps
		22·1	Mi. pn			14·2	Te. e			12·6	Mi. fs
		22·9	En. fn		24	9·6	Rh. fn			13·4	Di. pn
	16	8·9	Te. fn			9·6	Mi. pn			14·4	En. fs
		9·4	Mi. fs			10·5	En. pn			18·0	Mi. fn
		13·3	Di. fn			12·8	Te. w			19·5	Te. fs
		14·8	Mi. fn			15·0	Mi. ps		3	6·9	En. pn
		15·3	En. ps			18·3	Di. fn			11·2	Te. fn
		15·9	Te. pn			18·6	Rh. pn			11·2	Mi. fs
		16·5	Rh. w			20·6	En. ps			13·0	Rh. fs
		20·7	Mi. pn			20·6	Te. ps			14·4	Di. ps

1891.	h			h			h	
Mar. 3	16·6	Mi. fn	Mar. 9	19·6	Mi. ps	Mar. 15	17·5	Te. ps
	16·9	En. ps		20·9	En. fn		18·4	Rh. w
	18·2	Te. pn		22·0	Di. e		21·8	Di. fn
	22·2	Di. fs	10	4·5	Tit. inf. ♂ n. 15″	16	5·6	Di. pn
4	9·4	En. fn		6·9	Mi. fn		7·2	En. fs
	9·8	Te. ps		7·5	Rh. pn		8·4	Te. e
	9·8	Mi. fs		8·7	Te. fs		9·9	Mi. ps
	10·7	Di. e		10·5	Di. fn		15·8	Mi. fs
	11·6	Rh. e		12·8	Mi. pn		16·2	Te. fn
	15·2	Mi. fn		13·3	En. ps		17·0	Rh. ps
	15·7	En. pn		16·5	Te. e		17·3	En. fn
	16·8	Te. fs		18·2	Mi. ps		18·2	Di. w
	21·1	Mi. pn		18·3	Di. pn	17	6·7	Di. ps
5	7·0	Di. pn		19·7	En. fs		7·0	Te. w
	8·2	En. fs	11	6·1	Rh. w		8·5	Mi. ps
	8·4	Te. fn		6·8	Di. w		9·7	En. ps
	8·4	Mi. fs		7·3	Te. pn		14·4	Mi. fs
	10·2	Rh. fn		11·4	Mi. pn		14·5	Di. fs
	13·8	Mi. fn		12·1	En. pn		14·8	Te. ps
	15·4	Te. pn		15·1	Te. w		16·1	En. fs
	18·3	En. fn		16·8	Mi. ps		19·8	Mi. fn
	19·2	Rh. pn		19·4	Di. ps		21·8	Te. fs
	19·5	Di. w	12	6·0	Te. fs	18	5·7	Te. e
	19·8	Mi. pn		10·1	Mi. pn		7·1	Mi. ps
6	7·0	Mi. fs		13·7	Rh. fs		8·5	En. pn
	7·1	Te. ps		13·8	Te. e		9·7	Tit. sup. ♂ s. 16″
	8·1	Di. ps		14·6	En. fn		13·0	Mi. fs
	10·7	En. ps		15·5	Mi. ps		13·5	Te. fn
	12·5	Mi. fn		15·7	Di. e		15·5	Di. fn
	14·1	Te. fs		21·0	En. pn		18·4	Mi. fn
	15·9	Di. fs		21·4	Mi. fs		18·6	En. ps
	17·1	En. fs		21·6	Te. fn		20·5	Te. pn
	17·8	Rh. w	13	7·1	En. ps	19	4·3	Te. w
	18·3	Mi. pn		8·7	Mi. pn		5·8	Mi. ps
	21·9	Te. e		12·0	Di. pn		8·2	Rh. pn
7	5·7	Mi. fs		12·3	Rh. e		11·0	En. fn
	5·7	Te. fn		12·4	Te. w		11·7	Mi. fs
	9·5	En. pn		13·4	En. fs		11·8	Di. w
	11·1	Mi. fn		14·1	Mi. ps		12·1	Te. ps
	12·7	Te. pn		20·0	Mi. fs		17·1	Mi. fn
	16·4	Rh. ps		20·3	Te. ps		17·4	En. pn
	16·9	Di. fn	14	5·9	En. pn		19·1	Te. fs
	17·0	Mi. pn		7·3	Mi. pn	20	6·8	Rh. w
	19·6	En. ps		10·9	Rh. fn		8·1	Di. fs
	20·6	Te. w		11·1	Te. e		9·8	En. fs
8	9·7	Mi. fn		12·7	Mi. ps		10·3	Mi. fs
	11·4	Te. fs		13·0	Di. ps		10·8	Te. fn
	12·0	En. fn		16·0	En. ps		15·7	Mi. fn
	13·2	Di. w		18·6	Mi. fs		17·8	Te. pn
	15·6	Mi. pn		18·9	Te. fn		19·9	En. fn
	18·4	En. pn		19·9	Rh. pn		20·6	Di. e
	19·2	Te. e		20·8	Di. fs	21	5·4	Rh. ps
	21·0	Mi. ps	15	8·4	En. fn		8·9	Mi. fs
9	8·3	Mi. fn		9·3	Di. e		9·2	Di. fn
	9·5	Di. fs		9·7	Te. w		9·4	Te. ps
	10·0	Te. pn		11·3	Mi. ps		12·3	En. ps
	10·8	En. fs		14·8	En. pn		14·3	Mi. fn
	14·2	Mi. pn		17·2	Mi. fs		14·4	Rh. fs
	17·8	Te. w						

1891.	h				h			h
Mar.21	16·4 Te. fs	Mar.30	16·4 En. pn	Apr. 7	8·2 Rh. w
	17·0 Di. pn	31	6·8 Di. fs		9·1 Te. ps
22	5·5 Di. w		8·9 En. fs		13·4 Mi. fn
	8·1 Te. fn		10·7 Te. e		15·4 Di. w
	12·9 Rh. e		11·7 Mi. ps		15·5 En. fn
	15·1 Te. pn		13·6 Rh. e		16·1 Te. fs
	18·0 Di. ps		17·6 Mi. fs	8	6·7 Rh. ps
23	6·7 Te. ps		18·5 Te. fn		7·7 Te. fn
	11·5 Rh. fn	Apr. 1	7·8 Di. fn		7·8 En. ps
	13·7 Te. fs		9·4 Te. w		11·7 Di. fs
	14·3 Di. e		10·4 Mi. ps		12·0 Mi. fn
24	5·4 Te. fn		11·2 Rh. fn		14·1 En. fs
	10·6 Di. pn		11·4 En. ps		14·7 Te. pn.
	12·4 Te. pn		15·6 Di. pn		15·7 Rh. fs
	19·1 Rh. w		16·3 Mi. fs		17·9 Mi. pn
	20·2 Te. w		17·2 Te. ps	9	6·4 Te. ps
25	11·0 Te. fs		17·7 En. fs		6·6 En. pn
	11·6 Di. ps	2	8·0 Te. e		10·6 Mi. fn
	17·7 Rh. ps		9·0 Mi. ps		12·8 Di. fn
	18·8 Te. e		10·2 En. pn		13·4 Te. fs
	19·4 Di. fs		14·9 Mi. fs		14·1 Rh. e
26	2·0 Tit. inf. ♂ n. 16′		15·8 Te. fn		16·5 Mi. pn
			16·6 Di. ps		16·7 En. ps
	7·9 Di. e		19·8 Rh. w		20·6 Di. pn
	9·7 Te. pn		20·3 En. ps		21·2 Te. e
	13·3 Mi. pn		20·3 Mi. fn	10	9·1 Di. w
	13·8 En. pn	3	6·7 Te. w		9·1 En. fn
	17·5 Te. w		7·6 Mi. ps		9·2 Mi. fn
	18·7 Mi. ps		7·7 Tit. sup. ♂ s. 17″		12·0 Te. pn
	20·5 Di. fn				12·7 Rh. fn
27	8·3 Te. fs		12·7 En. fn		15·1 Mi. pn
	10·9 Mi. pn		12·9 Di. e		15·5 En. pn
	16·1 Te. e		13·5 Mi. fs		19·9 Te. w
	16·3 En. fn		14·5 Te. ps		23·8 Tit. inf. ♂ n. 18″
	16·8 Di. w		18·4 Rh. ps		
	17·3 Mi. ps		18·9 Mi. fn	11	10·7 Te. fs
28	7·0 Te. pn		19·1 En. pn		13·7 Mi. pn
	8·7 En. ps	4	9·2 Di. pn		17·9 Di. e
	8·9 Rh. pn		11·5 En. fs		18·0 En. fn
	10·5 Mi. pn		12·1 Mi. fs		18·5 Te. e
	13·1 Di. fs		13·1 Te. fn	12	9·3 Te. pn
	14·8 Te. w		17·5 Mi. fn		10·4 En. ps
	15·1 En. fs		20·1 Te. pn		12·4 Mi. pn
	15·9 Mi. ps	5	10·3 Di. ps		14·2 Di. pn
29	5·6 Te. fs		10·7 Mi. fs		16·8 En. fs
	7·5 Rh. w		11·8 Te. ps		17·2 Te. w
	7·5 En. pn		14·0 En. ps	13	8·0 Te. fs
	9·1 Mi. pn		16·1 Mi. fn		9·2 En. pn
	13·4 Te. e		18·1 Di. fs		11·0 Mi. pn
	14·1 Di. fn		18·8 Te. fs		15·3 Di. ps
	14·5 Mi. ps	6	6·6 Di. e		15·8 Te. e
	17 6 En. ps		9·3 Mi. fs		16·4 Mi. ps
30	6·0 Rh. ps		9·6 Rh. pn	14	6·6 Te. pn
	7·7 Mi. pn		10·4 Te. fn		9·6 Mi. pn
	10·1 En. fn		12·8 En. pn		11·6 Di. e
	10·4 Di. w		14·7 Mi. fn		11·7 En. fn
	12·1 Te. w		17·4 Te. pn		14·5 Te. w
	13·1 Mi. ps		19·1 Di. fn		15·0 Mi. ps
	15·0 Rh. fs	7	8·0 Mi. fs		18·1 En. pn

1891.	h			h			h
Apr. 15	7·9 Di. pn	Apr. 25	14·4 Te. pn	May 5	14·5 Mi. fs
	8·2 Mi. pn		17·0 Mi. pn		16·6 Te. ps
	10·3 Rh. pn		17·2 En. pn	6	7·5 Te. e
	11·5 En. fs	26	8·3 Rh. ps		9·0 Di. e
	13·1 Te. e		9·6 En. fs		9·9 En. fn
	13·6 Mi. ps		9·7 Mi. fn		13·1 Mi. fs
16	8·9 Rh. w		13·1 Te. fs		15·3 Te. fn
	8·9 Di. ps		15·6 Mi. pn		16·3 En. pn
	11·8 Te. w		17·3 Rh. fs		16·7 Rh. e
	12·2 Mi. ps	27	7·6 Di. ps	7	8·7 En. fs
	13·1 En. ps.		8·3 Mi. fn		11·7 Mi. fs
	16·7 Di. fs		11·8 Te. pn		13·9 Te. ps
17	7·5 Rh. ps		12·1 En. ps		15·3 Rh. fn
	10·4 Te. e		14·2 Mi. pn		17·1 Mi. fn
	10·8 Mi. ps		15·4 Di. fs		17·9 Di. w
	11·9 En. pn		15·9 Rh. e	8	10·3 Mi. fs
	16·5 Rh. fs	28	10·4 Te. fs		11·2 En. ps
	16·7 Mi. fs		10·9 En. pn		12·6 Te. fn
	17·8 Di. fn		12·8 Mi. pn		14·2 Di. fs
	18·2 Te. fn		14·5 Rh. fn		15·7 Mi. fn
18	9·1 Te. w		16·5 Di. fn		17·6 En. fs
	14·1 Di. w	29	9·1 Te. pn	9	9·0 Mi. fs
	15·1 Rh. e		11·5 Mi. pn		10·0 En. pn
	16·9 Te. ps		12·8 Di. w		11·3 Te. ps
19	5·4 Tit. sup. ♂		13·5 En. fn		14·4 Mi. fn
	s. 18″		16·9 Mi. ps		15·2 Di. fn
	7·7 Te. e		16·9 Te. w		18·3 Te. fs
	10·4 Di. fs	30	7·7 Te. fs	10	9·9 Te. fn
	13·7 Rh. fn		9·1 Di. fs		11·5 Di. w
	15·5 Te. fn		10·1 Mi. pn		12·6 En. fn
20	6·4 Te. w		12·3 En. fs		13·0 Mi. fn
	11·5 Di. fn		15·5 Mi. ps		16·9 Te. pn
	14·2 Te. ps		15·5 Te. e	11	7·9 Di. fs
21	7·8 Di. w	May 1	10·2 Di. fn		8·6 Te. ps
	8·2 En. fn		14·1 Mi. ps		11·4 En. fs
	11·2 Mi. fs		14·2 Te. w		11·6 Mi. fn
	12·8 Te. fn		14·8 En. ps		15·6 Te. fs
	14·5 En. pn	2	12·7 Mi. ps		17·5 Mi. pn
	16·6 Mi. fn		12·8 Te. e		20·4 Di. e
22	7·0 En. fs		13·6 En. pn	12	7·2 Te. fn
	9·8 Mi. fs	3	11·3 Mi. ps		8·9 Di. fn
	11·5 Te. ps		11·5 Te. w		10·2 Mi. fn
	15·2 Mi. fn		11·9 Rh. pn		12·7 Rh. pn
	16·6 Di. e		15·3 Di. e		13·9 En. ps
	17·0 En. fn		16·1 En. fn		14·2 Te. pn
	18·5 Te. fs		17·2 Mi. fs		16·1 Mi. pn
23	10·1 Te. fn	4	8·6 En. ps		16·7 Di. pn
	12·9 Di. pn		9·9 Mi. ps		20·3 En. fs
	17·1 Te. pn		10·2 Te. e		20·4 Tit. inf. ♂
24	8·8 Te. ps		10·5 Rh. w		n. 18″
	11·1 Rh. pn		11·7 Di. pn	13	8·8 Mi. fn
	14·0 Di. ps		14·9 En. fs		11·3 Rh. w
	15·8 Te. fs		15·9 Mi. fs		12·7 En. pn
25	7·4 Te. fn	5	3·7 Tit. sup. ♂		12·9 Te. fs
	9·7 Rh. w		s. 18″		14·7 Mi. pn
	10·3 Di. e		8·8 Te. w		17·8 Di. ps
	10·8 En. fn		9·1 Rh. ps		20·1 Mi. ps
	11·1 Mi. fn		12·7 Di. ps		20·7 Te. e

1891.	h		h		h
May 14	9·9 Rh. ps.	May 14	18·9 Rh. fs	May 15	14·0 En. fs
	11·5 Te. pn		19·4 Te. w		17·4 Mi. ps
	13·4 Mi. pn	15	7·7 En. ps		17·5 Rh. e
	14·1 Di. e		10·2 Te. fs		18·0 Te. e
	15·2 En. fn		10·4 Di. pn		
	18·8 Mi. ps		12·0 Mi. pn		

Note on Errata to Vol. II. of Oppolzer's 'Bahnbestimmung' recently published in the 'Monthly Notices.' By Lieut.-Gen. J. F. Tennant, R.E., F.R.S.

In Vol. l., p. 472 of the *Monthly Notices* I have given some errata to the volume of Oppolzer's great work. Since then Mr. Leuschner, of the Lick Observatory and University of California, has given a very extensive list, and has referred to my errata, as to some of which he expresses doubt.

I am sorry to say that the correction of sign in the formula in page 108 is erroneous. And as regards that given for p. 148, though correctly copied from my note, it must have had a wrong reference, for it evidently cannot refer to this page.

In the value of log. fig. 3, p. 111, Mr. Leuschner gives a correction of sign, but no correction to the figures. The subscript n had been erased in my copy, and so missed my notice; but the change of a figure is necessary, and so are all the rest of the numerical corrections. Also the sign of $\Delta \Sigma (x)$ on Oct. 27 should be $+$.

Mr. Leuschner has performed a service to students, who will, it is to be hoped, be saved some doubts when going carefully through this work.